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Cornell Meeting of the American Electrochemi- cal Society.

The Ithaca meeting of the American Electrochemical So-
ciety—a full report of which will be found in this issue—was
a most decided success. In the atmosphere of Cornell the
members and guests of the Society all felt at home, and the
beauty of the town revealed itself loftily in the glory of Spring.
Indeed, the view from the Chemical Laboratory down to the
lake and the valley in the tender green of the young May, was
an inspiration in itself. For the hospitality extended to the
Society, not enough credit can be given to the local com-
mittee in general and to the distinguished retiring president
of the Society, Prof. Wilder D. Bancroft, in particular. All
visits, excursions and social functions were extremely enjoy-
able, while the programme of the three sessions, devoted to the
reading of papers, was exceptionally well balanced. There
were presented thirty papers in all, dealing in about equal
parts with theoretical and practical subjects. Ten papers were
contributed from engineers and chemists in professional prac-
tice, twenty papers from universities, among which Cornell
figured with seven papers, Wisconsin with six, Massachusetts
Institute with three, Lehigh, Michigan, Princeton and Karls-
ruhe (Germany) each with one paper. The only drawback
was the comparatively small attendance, and it is to be feared
that no radical change can be expected with regard to this
point if the policy of holding two meetings a year is to be
kept up as heretofore. Perhaps the compromise plan, men-
tioned on another page of this issue, and recommending one
annual principal meeting in Spring and a second and secondary
meeting in Autumn in New York City, may prove the best
solution of the problem. Under such an arrangement every
member would make it a point to try to attend the meeting
in Spring, which would be held in a different city each year.
The second meeting in Autumn should logically be held in
the city which is the official seat of the Society; but this would,
in the present case, defeat the purpose of the arrangement.
New York City seems the most suitable place on account of
its large resident membership, and for the other reason that
many professional men have to visit New York in the Autumn,
and could combine this visit with the attendance of the
meeting.

The Chemistry of Electric Lamps.

Few people realize the fundamental importance of the proper
solution of the chemical problems which underlie almost any
engineering proposition. The user of electric lamps considers
them as a product of the electrical industries, which is, of
course, true. He also understands that electrical engineering
knowledge is required for the proper installation of the lamps.
But very few realize that, for instance, the production of the
filament of an incandescent lamp is essentially a problem of

chemical engineering. Mr. Edison's momentous pioneer work of twenty-six years ago was the foundation of the modern electric lighting industry. But in giving to the world the first commercial electric incandescent lamp, Mr. Edison was essentially a chemical engineer. Any real progress in the invention of new lamps must be ultimately based on chemical research work. The truth of this statement will be evident when we look over the progress that has recently been made in this field. It is a timely subject. For we are now right in the midst of a development the end of which nobody can yet prophesy. It is unnecessary to dwell on the rapid development of electric lighting by incandescent as well as arc lamps during the last twenty years of the nineteenth century. It seemed that the gas lighting industry was doomed, that the electric lamp would practically replace the gas lamp just as the latter had replaced the oil lamp. This would probably have occurred if the chemical engineering work of Dr. Auer Freiherr von Welsbach had not saved the situation for the gas industry by the invention of the gas incandescent lamp. Then came the natural reaction. The gas people pushed their new lamp to the utmost, and it is no exaggeration to say that electric central station engineers in this country as well as in Europe got scared. It became evident that electric lighting, to be able to compete successfully, must be cheapened. New and more efficient electric lamps had to be invented. This is the other reaction which has set in during the last years and which is now proceeding with a surprisingly high reaction velocity.

* * *

It is again the chemical engineer who does the work. Dr. Auer von Welsbach has again come to the front with his osmium lamp; Dr. von Bolton and his chemical coworkers of the Siemens & Halske Co., with the tantalum lamp; Dr. Whitney, of the research laboratory of the General Electric Co., with the graphitized filament lamp, and still more recently Dr. Kuzel and others with the tungsten lamp. Then we hear of a zirconium lamp, and surely there will be others. A peculiar incident of this development is the reaction of the chemical research work in rare elements on both the steel industry and the electric lighting industry. In the steel industry a revolution has been brought about by the introduction of high-speed tool-steels, and this was made possible by the introduction of ferro-alloys. It is important to have the ferro-alloys as pure as possible, with as little carbon as possible, in order not to introduce any undesirable elements into the steel. For many purposes it is preferable to introduce the element with which the iron is to be alloyed not in its elemental form, but as a ferro, on account of the decreased melting point. For a filament of an electric incandescent lamp it is even more important to have the greatest possible purity; here the melting point should be as high as possible, since the higher the temperature at which the lamp is operated the higher its efficiency. As a general proposition, it will be important that the filament shall be in the purest elemental form, since any small addition of an impurity considerably decreases the melting point. The enormous amount of research work on rare elements which has recently been done to further the above mentioned commercial ends, has made it clear how little we have known before of the physics and chemistry of these elements. Thus von Bolton claims that nobody before him ever produced pure tantalum; he seems to be backed up in this by the United States Patent

Office, if we consider the extremely broad claims which have been allowed to him, as mentioned in the Analysis of Current Electrochemical Patents in our present issue.

* * *

In connection with the latest comer, the Kuzel lamp, for which an exceedingly high efficiency (1 candle-power per watt, and even better) is claimed, one special point is of particular interest. This is that Dr. Kuzel brings the metal first into the colloidal state, then puts it into filament form and dries it. The filament is then a conductor of the second class (an electrolytic conductor). By electrically heating it, the nature of the filament changes; it becomes a conductor of the first class (a metallic conductor). The filament is then ready for use. Thus the study of colloids—which has been considered by many a very interesting, but exceedingly theoretical subject, barren of practical applications—has led in this case to a very promising and commercially important result. A few words may be added on arc lamps. In this field, too, it is chemical research work which has given us a new lamp—the “flaming arc lamp.” Its feature is the impregnation of the carbons with certain chemicals. The evaporation of the latter results in the production of an artificial, highly ionized atmosphere. Light is given off not only from the terminals of the carbons, but also from the arc itself, which can be drawn out much longer than in ordinary arc lamps. This results in a higher efficiency and in the possibility of producing any desired color effects. Taken as a whole, the progress already made in the invention of new electric lamps is very gratifying, but even greater progress may be confidently expected in the near future.

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New Developments at Broken Hill.

The great mines of the Barrier Reef at Broken Hill, Australia, form one of the greatest and richest bodies of ore known to the mining world. The deposit is comparable in size and general uniformity to the celebrated Rio Tinto copper mine of Spain. The typical ore assays about 16 per cent lead, 11 oz. silver, and 15 per cent zinc, and is of the character described as a “complex sulphide.” For years this has been worked only for the recovery of the argentiferous galena by careful wet concentration, and the zinc values have accumulated in vast heaps of tailing to an aggregate tonnage of 6,000,000 tons. Such an amount of potential mineral value has been the means of stimulation to much metallurgical experimentation in the past twenty years, but no real commercial process was developed until recently. Magnetic separation has been only moderately successful, and it is to the “acid flotation” process that can be ascribed the final unlocking of this stored mineral wealth.

* * *

The theory of this process has been discussed in our columns recently, but these theories are but inadequate explanations of the facts. Both the “Potter” process and the “Delprat” process are based simply on actual experimental ground-work. These processes both produce a zinc concentrate of fair grade (40-45 per cent zinc), with small recoverable values of lead and silver. The several companies preparing to produce the zinc concentrate have contracted with large companies to absorb this tonnage at their plants on a sliding scale basis, which we described in a late editorial. Such an ar-

rangement is eminently fair and satisfactory to each contracting party. The losses in the wet concentration and the following "flotation" concentration are high, but as this is compensated for by the low cost of mining and of the combined treatment, the result is a very nice margin of profit on the zinc value of the original ore.

* * *

The total reserves, both in ore and tailings, foot up to the enormous gross value of, in round numbers, seven hundred million dollars, distributed as follows: Lead, \$200,000,000; silver, \$100,000,000; zinc, \$400,000,000. Of course, these figures are subject to deductions for mining and treatment costs and losses and market fluctuations, so that the probable net profit is only a fraction of these astounding figures, but still large enough. Market fluctuations will be controlled to some extent by a policy of regulating supply of ore to suit increasing demands for metal. Such a course is wise and conservative business. We can look to these great mines in a way as a balance wheel in the markets for these three metals in Europe to absorb irregularities in the trade. In conclusion, it should be stated that the innovation in the metallurgical treatment which has so expanded the future of Broken Hill as a zinc producer was due originally to an observation of the floating of the sulphide particles in a beaker during a chemical analysis. So much for the fecundity of an idea.

Industrial Development Increasing the Productivity of Capital.

The definitions of political economists often vary with the individual thinker. With regard to their great element, "capital," there is, however, little disagreement. Capital is stored-up wealth, available for man's economic needs; and interest is in a measure the average and normal rate of the growth of capital. There is a natural correction for insurance or the cost of protecting capital against economic decrease. And the net interest return sometimes is negative, as in the case of silverware stored in a vault, where productivity is nil and cost of protection considerable. It can thus be laid down as an axiom that any general tendency which increases the productivity of capital increases the rate of interest. Naturally, in a new country as was the West of the United States forty years ago, the interest rate was high, because the fertile prairies were being turned into farm lands by the influx of settlers. In Central America to-day the productive tropical sun does the work while man is so indolent that the natural resources are only touched. Therefore, 20 per cent per year is considered not at all usurious in Guatemala.

* * *

At the present boom period we perceive a gradual increase in rate of interest and a great increase in market price of that class of securities which have the final marginal share in the equity, as the common stocks of railroads and "industrials." The simplest and boldest explanation of this is to ascribe it to the great wave of prosperity that is now sweeping over North America. Just as England in the past century slowly and surely forged ahead to pre-eminence in commerce, so does America seem now to be undergoing lasting industrial growth. But a deep and critical search into the basic cause of this action would lead us to believe that it is the peculiar

combination of native adaptivity to changing environment of the American type with the great natural resources opened up by the progress of applied science. The advance in the use of the telephone and telegraph and in mail and shipping facilities all reduce "industrial friction" to a decreasing minimum. The widespread growth of technical engineering schools for the embryonic engineer and engineering societies for the older men, diffuse accurate knowledge of technology. And likewise the wonderful rise of the technical and commercial press is having a profound effect, greater indeed than most of us imagine.

* * *

New developments in engineering create unlooked-for values of the natural resources. For instance, the largest item of the fundamental wealth of the United States Steel Corporation is its holdings of Mesabi ore lands. Due to the physical fineness of these ores it was impossible in the early "nineties" to sell these ores to any blast furnace, and until as late as 1897 these lands possessed but little cash value in spite of high iron content and other valuable chemical properties. However, due to a gradual increase in the practical knowledge how to treat these ores, to which hundreds of individuals each has contributed his increment, these ores have assumed an enormous value, about the "psychological moment" when the great iron and steel merger took place. In the case of non-Bessemer or phosphatic ores the change was a much more gradual one, covering a period of nearly two decades in this country. In the copper industry the change has been very marked. One large Western mine some twenty years ago was throwing away a slag analysing 12 per cent copper. Now its average of ore mined is less than one-quarter of this. The immense value of phosphatic rocks in the South is all due to the application of a simple chemical reaction—of sulphuric acid rendering native phosphate available to plant growth. The electrolytic refining of copper, the other various electrochemical industries of aluminium, calcium carbide, carborundum, etc., have all created new national assets. The cyaniding of gold ores, the improvements in lead smelting, in the zinc industry and in the metallurgy of minor metals have had a like effect. By-product coke ovens, electrical transmission of power, high-speed tool-steel, oil refining, the packing of meats, agriculture, simply continue the list of industries in which the widespread use of modern methods and application of scientific facts have created values by the adherence to the ideal.

* * *

Though there are countless failures to chronicle, yet the sum of this all is progress. And best of all, due to modern ways of diffusing correct principles, this progress is made more efficiently now than before. In the future, we can expect greater advance, some few startling, but oftener a simple and sure evolution resulting in operations done on a large and diverse scale, but with greater usefulness to the body politic. And as a result of this tendency, we can expect the rate of interest to measure this productivity of capital at a slowly increasing normal rate, with only slight waves of recession until some great counter current nullifies this current. But the all-pervading advance of scientific engineering and philosophical commercialism does but render the future bright. And in the United States the consistent bull always wins out in the long run.

Faraday Society.

The twentieth ordinary meeting of the Faraday Society was held on Tuesday, May 15, 1906, Dr. F. Mollwo Perkin, treasurer, being in the chair.

PLATINIZED PLATINUM ELECTRODES.

Mr. H. D. Law read a paper entitled "Behavior of Platinized Electrodes." The author desired to find an electrode on which the reduction of the aromatic-aldehydes and similar easily reducible compounds could not be effected. Platinized platinum, as being the metal from which hydrogen is liberated at the lowest potential, was tried as the cathode in an acidified alcoholic solution of benzaldehyde. At first, energetic reduction took place; the activity of this, however, diminished in successive experiments, and was extremely small after 12 hours' polarization. The cause of the reaction is obscure; it is probably catalytic in its origin.

Dr. N. T. M. Wilsmore drew attention to Tafel's work, which the author's results appeared to contradict.

Dr. F. Mollwo Perkin remarked on the differences between lead and platinum electrodes, and discussed the general bearing of the author's experiments.

ELECTROLYSIS OF FUSED ZINC CHLORIDE.

Mr. Julius L. F. Vogel read a paper on "The Electrolysis of Fused Zinc Chloride in Cells Heated Externally." The author begins by explaining that the work which formed the subject of the paper was carried out for the most part between 1898 and 1901, and could be conveniently divided into three periods. He then explains how the investigation came to be undertaken; the original inception of the process was due to the late F. Maxwell Lyte, who took out patents for a complex ore process involving the electrolysis of fused zinc chloride and for the dehydration of zinc chloride. The process as such was never investigated practically. The second period deals with the investigation of the dehydration of zinc chloride by evaporating under reduced pressure, and the electrolysis of the salt in a fused state in externally heated cells by Dr. O. J. Steinhart and the author jointly on behalf of the Smelting Corporation, Ltd. The various experiments and the apparatus employed for these experiments are described. The third period deals with the further investigations made after the United Alkali Co. had joined the Smelting Corporation in testing the process, and details are given of the work as carried out under the joint supervision of the author's firm and the chemical staff of the United Alkali Co. The author describes how the process was carried successfully to a stage when continuous electrolysis was carried on for eleven days and nights, and three cwt. of pure zinc was produced.

He then explains how, on the failure of the Smelting Corporation, the work was suspended, and finally abandoned, although further elaborate investigations were undertaken by the United Alkali Co. utilizing cells heated internally by the current.

The author finally reviews the work done in cells heated externally, and expresses his opinion that the process was "non-proven," and that it still offers possibilities of being carried to commercial success.

The paper is illustrated with sectional drawings of apparatus and lantern slides, prepared from photographs of the actual plant, were exhibited.

Dr. O. J. Steinhart referred to the production of zinc from zinc oxide by feeding the latter into a molten bath of chloride, after the fashion of aluminium electrolysis.

Mr. W. Murray Morrison mentioned some of the advantages of internal heating with regard to local inequalities of temperature.

Dr. H. Borns referred to the formation of zinc clouds diffused in the electrolyte under certain conditions, and consequent reduction of efficiency observed by Lorenz. He asked whether the addition of impurities, such as ammonium chloride,

had been tried. Evaporating with HCl was a method of dehydrating the chloride.

Mr. L. Gaster asked for information regarding comparative energy losses in externally and internally heated cells, and also regarding the consumption of carbon.

Dr. G. Rudolf (communicated), after reviewing the various methods proposed for dehydrating the chloride, affirmed that the author's was the only practicable one. He asked for information regarding the effect on the enamel of continuous heating with zinc chloride; his experience was that a perfect enamel was not obtainable.

Mr. J. L. F. Vogel, in reply, said that the use of a fused metallic cathode and proper temperature and other conditions prevented the formation of zinc cloud. Carbon losses depended greatly on the dehydration; they had not had opportunities of trying Acheson graphite. It was undesirable to add foreign substances, as these would accumulate in time; it was likewise impracticable to dehydrate in the fashion referred to by Dr. Borns. The difficulty in electrolyzing a solution of ZnO in fused chloride was that the solubility was slight, and at the high-current densities demanded by practice not sufficient oxide would pass into solution.

American Institute of Electrical Engineers.

The twenty-third annual convention of the American Institute of Electrical Engineers was held in Milwaukee, Wis., from May 28 to 31, and was a full success with respect to attendance (which was about 230), and the number and quality of papers presented, and was highly enjoyable in its social functions.

The president, Dr. S. S. WHEELER, who will retire in autumn, took occasion to introduce to the convention the new president-elect, Dr. SAMUEL SHELDON, of Brooklyn, N. Y.

Among the numerous papers presented there was one by President Wheeler, who discussed the topic, "Engineering Ethics." Electrical engineers are professional men, and as such they are under moral obligations to the public, to their clients and to the engineering society. This subject was discussed along broad lines, and later on a motion of Dr. C. P. Steinmetz was adopted that the Institute, through its president and board of directors, shall formulate a code of ethics to the membership for approval.

A paper by Prof. D. C. JACKSON dealt with economies derivable from the use of relatively small water powers of low head in the Middle West.

A very interesting paper by Mr. E. F. NORTHRUP discussed the measurement of temperatures by electrical means; we will give a longer abstract of this paper in our next issue.

MAGNETIC PROPERTIES OF ELECTROLYTIC IRON.

A paper which will certainly appeal strongly to our readers dealt with the magnetic properties of electrolytic iron, and had as authors Prof. C. F. BURGESS, of the University of Wisconsin, and Mr. A. H. TAYLOR.

In the introduction the authors remarked that they have made marked improvement recently in the purity of electrolytic iron. Two analyses were given. One sample contained no S, 0.013 Si, 0.004 P, no Mn, 0.012 C, 0.072 H; the other sample 0.001 S, 0.003 Si, 0.020 P, no Mn, 0.033 C, 0.083 H.

The electrolytic iron was made, of course, by the method of Burgess, which was described in our Vol. II., p. 183. The chief impurity in iron is hydrogen, and it has often been thought that this content of hydrogen is responsible for some of the peculiar properties of the iron, but the authors are not sure that there really exists a relationship between the hardness of the iron and the hydrogen content.

The authors are now making an extended investigation under a grant from the Carnegie Institution, of Washington, concerning the magnetic properties of electrolytic iron as

altered by heat treatment. The purpose of the investigation is to establish the relationship between coercive force, permeability, hysteresis constants and the temperature at which the iron is heated. The paper presented at Milwaukee is in form of a preliminary report.

Some curves were shown giving the results of the measurements. The authors first tested electrolytic iron which had not been subjected to heat treatment. The iron is evidently very hard; the coercive force is 18 dynes and the retentivity 10,000. It seems that a field of 210 dynes does not saturate the iron, although it carries the induction to the high value of 21,250. At the same time there is relatively little area added to the hysteresis loop by running the field so high.

The test ring was then heated for several hours at a temperature of 200° C., and magnetic tests were again made. They gave a curve almost identical with the first.

The ring was then unwound, embedded in magnesium oxide and heated for 8 hours at about 1,200° C. The ring was found to be much softer than at first, and on being tested with the step-by-step method, gave values for the magnetic induction 17 per cent lower than those obtained by the method of reversals. This difference was traced to magnetic viscosity, and a modified ballistic method was devised to eliminate the error.

The new curve obtained shows that a tremendous change has taken place in the iron with heating at 1,200° C.

The iron is now in the condition of a rather soft steel, with a coercive force of about 2.5 dynes, a retentivity of 12,500, and a large amount of magnetic viscosity in the steep parts of the curve. A second heating of the ring to over 1,200° C. produced no appreciable change in the magnetic properties.

The paper elicited a lively discussion, in the course of which Dr. C. P. Steinmetz stated that thirteen years ago, during some investigations concerning the permeability of pure iron, he had found a mixture of iron deposited by means of a mercury electrode, the mercury subsequently being boiled out, had a permeability of about 2. He stated that during recent years a considerable change had developed with reference to the conceptions of magnetization. Many of the materials which had previously been considered non-magnetic were now known to be magnetic to a small degree, and many materials which are non-magnetic in themselves are found to be magnetic when combined with other so-called non-magnetic materials. Thus a mixture of 60 per cent of copper, 20 per cent of aluminium and 20 per cent of manganese possesses high permeability although it contains no magnetic materials. The permeability of these materials is effected by heat in a manner essentially different from that which is true with reference to iron. The alloy above referred to when heated and cooled quickly is found to be very magnetic, having a permeability about equal to that of nickel. A powdered mixture of antimony and manganese in portions of 3 to 1 will show the lines of magnetic force in the neighborhood of a magnet. Alloys of manganese and zinc have been found to be quite magnetic. Experiments with the thermit process have shown that manganese is magnetic when combined with certain other materials. He expresses the opinion that it is not impossible to find certain alloys possessing permeabilities greater than that of iron, the importance of which to the electrical industries is extremely great.

Recent Practice in the Treatment of Tin-Tungsten-Copper Ores.

(Concluded from page 168.)

Each of the five distributing boxes in front of the Lührig vanners has two compartments, each of which supplies one-half of a double vanner. Four of these boxes take the original pulp from the large spitzkasten, whilst the fifth takes the middlings from the other four vanners, so as to allow of a separate retreatment of the middlings. The middlings from the

vanners are collected and pumped by a centrifugal pump to a small condensing spitzkasten, to remove the surplus water, and the bottom discharge of this spitzkasten passes to a distributing box from which each compartment feeds one-half of a double vanner.

The heads from the vanners are a high-grade concentrate, and go to the calciner, where they are roasted separately from the coarser concentrates of the Buss tables. This arrangement has been found to save some reclassifying of the roasted concentrates, and secures a better market for the coarse products. The concentrates from the Buss tables are unusually free from any silicious waste, and contain only the sulphides of iron, copper and arsenic, the oxides of tin and wolframite. They are of a very much higher grade of concentration than the average Cornish concentrates called "witts," and are separately roasted and then electromagnetically treated. The vanner concentrates, which contain much of the iron oxides originally in the ore, are of lower grade as compared with those from the Buss tables, and are, therefore, prior to their electromagnetic treatment, reclassified and enriched in ordinary convex Cornish buddles, in which the bulk of the iron oxides are removed and go to waste.

This enrichment by buddling would be avoided if a second magnetic apparatus were at the disposal of the company; but as the capacity of the magnetic separator is only about 6 tons per 24 hours, the enrichment of a portion of the concentrates becomes necessary in order to enable the magnetic separator to deal with the whole of the concentrates. The vanner concentrates are, after enrichment, dried in a furnace of the reverberatory type. This drying is necessary, as the Wetherill magnetic separator requires the material to be in a very dry form. Formerly a drying furnace was used, having a bed of cast-iron plates on which the concentrates were spread, the plates being heated by a fire underneath, but the capacity of this open furnace is very much smaller than that of the closed reverberatory type. A revolving tube furnace of the Bruckner type, with provisions for catching the dust, would no doubt be the best furnace for drying purposes.

The milling and dressing costs during June last for 2,540 tons of ore crushed amounted to 69.2 cents per ton, a low figure, due to the extensive use of labor-saving machinery, but which the author expects to see brought to a lower figure through the use of a magnetic separator. In his concluding pages the author attacks Cornish metallurgical methods in general. He points out that "the success of the mill as regards high percentage (the loss being only 11.4 per cent) recovery at low cost upon a comparatively low-grade ore, is principally due to the introduction of a thorough system of classification and to the use of side discharge tables, which produce middle products, and as regards the separation of the denser minerals the success is especially due to the inclusion of electromagnetic separation in the scheme. Notwithstanding the work done in a few mines during recent years, as a general rule, classification has not received the attention it deserves in Cornwall; indeed, many of the Cornish tin dressers and mine managers regard it as an altogether useless incumbrance, and at only a few tin mines in the county has any attempt at classification even been made.

"In addition to classification, another important point was overlooked at the time when Frue vanners were introduced at the Cornish mines, i. e., graduated crushing. Tin usually occurs in a very fine state of division in the Cornish ores, and therefore requires fairly fine crushing; but the reason why the whole of the ore should be pounded into slimes to start with is difficult to understand, though upon most Cornish dressing floors this is done.

"Slimes are the bugbear of the dresser, and needless sliming is always to be deprecated, yet little care is taken in Cornwall to reduce the proportion of slimes in the pulp; indeed, in many cases everything seems to have been done to increase the proportion. Punched stamped grates are still strenuously de-

fended by the Cornish dresser, although owing to the unduly large extent of the blind places as compared with the open spaces in the grate there is an area entirely out of all proportion, and one that gives an abnormally small discharge. Cornish men are conservative in the extreme, and love to adhere to old methods. When abroad they are more open to modern methods and machinery, but at home they are slow in introducing them. The mines have often low-grade ores, and, therefore, especially require appliances for saving time and labor. The author firmly believes that with modern methods and machinery many Cornish mines could be profitably worked, and when this has once been realized the influx of capital to the county will be stimulated, and Cornwall, with its undoubtedly great mineral wealth, will once more regain its old prosperity."

The paper being a lengthy and contentious one, elicited considerable discussion. Indignant repudiation of incompetence was the keynote of many of the speeches. For instance, Mr. Arthur Thomas, of the Dolcoath mine, sent a caustic and lengthy communication, which called into question the accuracy of the vanning-shovel method of computation. It was further pointed out "that practice has disproved the theory that classification is essential for concentration on the vanner, and the custom obtaining is thoroughly justified by the excellent concentration resulting. Evidently the author is satisfied with the treatment peculiarly adapted such a singular ore as his own, but it would be unwise to generalize from this one instance. The balance of the evidence of practice, certainly against the theory of classification in every instance previous to concentration on vanners, and those who hold that classification is essential to close concentration, can certainly not have had an opportunity of studying all the facts under varying conditions of working. The author could not be taken seriously in respect to the unwarrantable assertion that 'why the whole of the ore is pounded into slimes to start with, is difficult to understand, though upon most Cornish dressing floors this is done.' This is not in accordance with fact, and a visit to most of the Cornish dressing floors will convince him that no such lamentable ignorance exists.

"Such strictures in this and other respects on the practice obtaining generally in the mines of Cornwall, are unjustified, and exhibit a lack of knowledge and appreciation of the circumstances."

The writer said he did not hold a brief for Cornishmen, but he suggested that perhaps the conservatism alleged might indicate more knowledge and proper appreciation of old methods and their present-day usefulness in justified circumstances than is generally supposed; but Cornishmen generally would no doubt be relieved to hear that there is some chance for them when they go abroad.

Mr. Walter MacDermott followed in very much the same vein. He thought that Mr. Dietzsch was speaking without much experience of what had been done beforehand. He had great sympathy with the author's conclusions, because he himself made the very same mistake more than twenty years ago, and not only he thought the same, but he wrote the same. But facts were things which must take precedence of any theory, and the almost universal experience of men in the mining world in connection with material that had been stamped to a grade sufficiently fine for a Frue vanner to begin with was that classification had no advantage. Now, that was a serious difference to be raised between two authorities, or two writers, one stating that it was the practice of a large number of men, for a great many years, on various ores all over the world. The theory of the need for classification had frequently cropped up. It was the natural outcome of some of the older books on concentration. He remembered himself, in writing his first description of the Frue vanner and its work, with the fear of Rittinger in his heart, that he made the statement that the better the classification the better would be the work of the Frue vanner. But it was not so, and there

must be some failure in a theory which did not agree with the results of practice. He had long ago determined to his own satisfaction that there were elements in the working of the concentrator which made it very difficult to theories with regard to the best results that could be obtained. The elements of inertia, of momentum, of flowing water, of adhesion to a surface, were all elements which might be individually stated; but the combined effect of which depended on the motion and the construction of the machine.

Mr. E. H. Davies considered that there was evidence of considerable loss, and that he believed the costs of dressing to be greatly in excess of that recorded by the author. For his part he agreed with Mr. Dietzsch, that with modern methods and machinery many Cornish mines might regain their prosperity. Mr. J. G. Green stated that if he were now going to erect a mill he would install the closest possible classification or sizing before attempting to get out the concentrates. Other speakers, such as Dr. Rose, Prof. Bauerman and Prof. Gowland, discussed the details of the roasting of the ore. Mr. D. A. Louis regarded classification as not always indispensable—at Dolcoath it was unnecessary, but with complex ores there was little doubt that close classification was of importance.

After further discussion Mr. H. C. Jenkins replied briefly, on behalf of the author, to several of the points raised, leaving Mr. Dietzsch, who was then in Burmah, to reply in writing to the discussion as a whole.

CORRESPONDENCE.

Kryptol.

To the Editor of Electrochemical and Metallurgical Industry:

SIR:—In the *ELECTROCHEMICAL AND METALLURGICAL INDUSTRY* of April, 1906, page 148, you give a synopsis of an article by J. Bronn on "Kryptol," and it is said that this "is not simply granulated carbon, but a mixture of carbon, graphite, sand, clay and other silicate, carborundum, etc."

In 1904 we determined the ash in a sample of kryptol and found that it contained 0.24 per cent (*ELECTROCHEMICAL AND METALLURGICAL INDUSTRY*, January, 1905, p. 5). Recently another sample weighing 10 grams was used for an ash determination and found to contain 0.64 per cent ash. The ash was then treated with hydrofluoric and sulphuric acid to remove silica and get iron, aluminium, etc., into solution. The insoluble matter that remained was then examined carefully under the microscope, and apparently consisted of a little unburnt graphite and some silica or silicates that had escaped the attack of the hydrofluoric acid. No carborundum was positively detected, although when magnified 450 diameters one crystal that looked something like carborundum was observed. However, there can be no doubt that any mere trace of carborundum which might have been present could have no effect on the kryptol as a resistor material. Any specimens we have had at our laboratory may be considered simply as a mixture of amorphous and graphitic carbon. Apparently, therefore, the kryptol described by Mr. Bronn differs from that which is offered for sale in this country under that trade name. It would be interesting to learn where kryptol of the composition mentioned by Mr. Bronn may be purchased.

The use of a mixture of carbon and carborundum would be interesting, but the very large thermal coefficient which characterizes the resistivity of carborundum might prove troublesome.

As to the admixture of silica and silicates in a granular carbon resistor, these would prove very objectionable after a certain temperature was reached, this temperature being that at which reactions occur between carbon and these compounds, thus introducing a permanent change in the resistivity of the material.

FRANCIS A. J. FITZGERALD.

FitzGerald & Bennie Laboratories,
Niagara Falls, N. Y., May 4.

CORNELL MEETING OF THE AMERICAN ELECTROCHEMICAL SOCIETY.

The ninth general meeting of the American Electrochemical Society was held at Ithaca, N. Y., on the first three days of May. Since we comment on the general features of this highly pleasant and successful meeting elsewhere in this issue, we will go in this report at once *in medias res*.

TUESDAY SESSION.

The first session was called to order on the morning of May 1 in the lecture room of the Chemical Laboratory (Morse Hall) by President Bancroft, who introduced the distinguished president of Cornell University, Dr. J. G. Schurmann.

In his graceful speech of welcome Dr. Schurmann pointed out that the founder of Cornell University had always insisted on the double purpose of the University: to discover and teach the truth with regard to Nature, and to apply this truth to the improvement of man's conditions. Since the American Electrochemical Society endeavors to fulfill the same double purpose, Dr. Schurmann heartily welcomed its members, and said they would surely feel at home in the atmosphere of Cornell.

President Bancroft expressed to President Schurmann the thanks of the Society, and a short business meeting followed. The reports of the secretary and treasurer will be printed as circulars.

Secretary Sadtler read the report of the tellers on the results of the recent election, which are as follows:

President (for one year), Mr. Carl Hering, Philadelphia, Pa.
Vice-Presidents (for two years), Col. Samuel Reber, Washington, D. C.; Dr. J. W. Richards, Bethlehem, Pa.; Dr. S. P. Sadtler, Philadelphia, Pa.

Managers (for three years), Mr. E. G. Acheson, Niagara Falls, N. Y.; Prof. C. F. Burgess, Madison, Wis.; Mr. C. J. Reed, Philadelphia, Pa.

Secretary (for one year), Mr. S. S. Sadtler, 39 South Tenth Street, Philadelphia, Pa.

Treasurer (for one year), Mr. P. G. Salom, Philadelphia, Pa.

Some other business announcements were made during the following sessions. The Frenzel prize for a paper on the production and uses of rare metals has been awarded to Mr. G. Gin, of Paris, France. Mr. Gin's voluminous memoir (in French) will be kept in the archives of the Society.

The first grant of \$100 from the Society's funds for special research work has been awarded to Dr. A. T. Lincoln, of the University of Illinois, for an investigation of the electrolytic corrosion of brass and special bronzes. Dr. Lincoln will report on the results of his research at the next annual meeting in 1907.

The question whether one or two meetings shall be held each year has not yet been definitely settled. It seems that the majority of the members favor a compromise by which the main annual meeting is to be held in Spring, at a place to be determined upon each year, while a second and secondary meeting shall be held in autumn in New York City. The idea is that many members, not residing in New York, visit New York regularly in autumn for professional reasons. These, together with the large resident membership of New York, would insure a full success, while, on the other hand, such a meeting would not constitute too much of a burden on the time and the pocketbook of the members. A clause in a motion to that effect stipulates that no special entertaining shall be done by the New York members in connection with this meeting. If this arrangement is finally adopted, two volumes of Transactions will be issued as heretofore.

AN INSTRUCTIVE LABORATORY EXPERIMENT IN APPLIED ELECTROCHEMISTRY.

The first paper was presented by Prof. WM. H. WALKER, of the Massachusetts Institute of Technology, who pointed out that it is one of the most important functions of a laboratory experiment in applied chemistry, as distinguished from an experiment in general or pure chemistry, to enable the students to acquire an economic point of view. It is only by connecting the data obtained by experiments with the important economic considerations involved in the problem, that the experiment becomes an industrial one.

The author illustrated these views in detail in discussing a special problem which meets all requirements more or less perfectly. This is the preparation of bleaching liquor by the electrolysis of brine without a diaphragm. (Concerning commercial apparatus in this line of work, see the article by Dr. Walker in our Vol. I., p. 439.) The raw material is ordinary salt of known purity, and while the apparatus may take many forms, the following has been found convenient:

An Acheson graphite crucible, holding two liters, is saturated with paraffine, and made to serve as the container and also the anode. This is set in a cooling bath supplied with running water. The cathode is an inverted U (\cap) shaped piece of hard rubber, upon the outside edge of which is placed

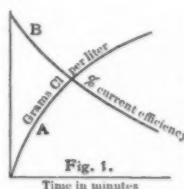


Fig. 1.

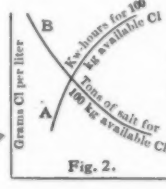


Fig. 2.

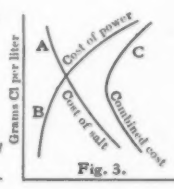


Fig. 3.

FIGS. 1, 2, 3.—ELECTROLYTIC PRODUCTION OF HYPOCHLORITE.

a piece of copper wire, forming the cathode. The wires from the two limbs of the \cap are united at the top, and by these the rubber frame is suspended from a bearing, such as a bicycle hub. By means of this bearing the cathode may be rotated, and the solution continually agitated. While the current density at the anode may be changed only by varying the current or the volume of solution in the crucible, the density at the cathode may be changed at will by substituting a different wire or by soldering on a metal plate. A current of 20 to 25 amps. at 6 volts is led into the cell through a mercury cup in the end of the bearing supporting the cathode, and back to the generator through an ammeter. Across the cell is connected a small voltmeter. At intervals of 10 minutes for the first half-hour, and after that each 20 minutes, a sample of the electrolyte is drawn from the cell by means of a 10-c.c. pipette, and analyzed for available chlorine by titration with tenth-normal sodium arsenite solution. At the same time the ammeter and the voltmeter are read and the temperature of the brine observed.

When the content of the chlorine ceases to appreciably increase, the experiment is interrupted and experimental data plotted, as shown by curves A and B in Fig. 1. As abscissæ are shown, the intervals of time elapsed from the beginning of the electrolysis, as ordinates in curve A, the grams available chlorine per liter, and in curve B the average current efficiency which has obtained from the start of the experiment up to the corresponding time. The calculation may be simplified and no

considerable error introduced if the average of the run be taken with respect to the volume, the current strength and the fall of potential across the cell.

In practical cotton bleaching, this liquor, however strong in available chlorine it may have originally been made, is diluted to about 3 grams per liter. When the available chlorine is exhausted by the cotton the residual liquor containing the salt is discarded. Salt will be economized by continuing the electrolysis as long as any hypochlorite is being formed. On the other hand, the hypochlorite thus formed may, on account of the low efficiency obtaining toward the end of the experiment, be costing more in power than is being saved in salt. The question then arises: for a given strength of brine, assume 200 grams NaCl per liter, and for a given quantity of available chlorine assume 100 kg., at what concentration of hypochlorite is it most economical to stop? At what point does the cost of electricity consumed overbalance the saving made in salt consumed?

To determine the relation of the decrease in the cost of salt as the content of hypochlorite is increased, to the increase in the cost of power under the same conditions, for a given weight of hypochlorite, the curves of Fig. 2 are drawn. From the electrochemical equivalent and the average voltage across the cell, the energy in kilowatt-hours is calculated, assuming that the process is carried out at 100 per cent efficiency. From this figure the energy necessary to produce 100 kg. available chlorine, at the efficiency obtaining when the solution contained from 1 to 10 grams available chlorine per liter is obtained, and is represented in curve *A*. The volume of brine, and hence the weight of salt necessary to make 100 kg. available chlorine at concentrations from 1 up to 10 grams per liter, may be easily calculated. This is given in metric tons in curve *B*.

We are now in position to determine the most economical concentration of available chlorine at any particular place, if we know the cost of salt and power prevailing there. For example, assume that salt can be bought for \$5 per ton, and power for 1¼ cents per kilowatt-hour. The cost of salt necessary to make 100 kg. available chlorine in the form of bleaching liquor at several different concentrations is given by curve *A*, Fig. 3. The cost of power is represented by curve *B*. By adding the abscissae for any one concentration we obtain the combined cost for the two factors, which is shown by curve *C*, with a minimum at \$36.80.

In discussing the problem with the class before beginning the experiment, a number of questions will arise. For example, assuming a constant cost for salt and power, what is the most economical concentration of brine to use? From theoretical considerations we know that the resistance, and hence the voltage necessary, will fall as the solution becomes more concentrated; this will decrease the cost of power but increase that of salt. The reduction at the cathode will be proportionately less as the relative number of Na and Cl ions increases; this will tend to increase the current efficiency, thus decreasing the cost of power, while the consumption of salt is made greater. Just what this relationship is, can be determined by having a certain number of students work at each concentration of salt, from 50 grams per liter, in steps of from 50 to 350 grams.

By assembling the resultant curves in one plot on the blackboard, the results are available for the entire class.

In the same way may be discussed and made the subject of investigation by members of the class for the benefit of all, the question of the relationship of current density to the cost of the process. It can be shown theoretically that to increase the size of the cathode, for example, decreases the resistance, and this lowers the energy consumed. But, on the other hand, it increases the amount of reduction of hypochlorite at the cathode, and hence decreases the current efficiency of the process, which increases the power necessary.

In the concluding part of the paper, Dr. Walker gave some

analytical considerations of Mr. Warren K. Lewis, who has reduced the curves of the above three figures to mathematical equations so that the concentration of available chlorine, which corresponds to the minimum cost of power and salt, may be calculated from a simple formula.

In the discussion which followed, Dr. J. W. Richards agreed with Dr. Walker that it was an excellent scheme to divide a class into groups working on the same problem under different conditions. Mr. Carl Hering suggested to reverse the abscissas and ordinates in Fig. 3, since the minimum total cost in Fig. 3 would then correspond to the lowest value of the ordinate of the curve. Dr. Richards said that the curve would then directly illustrate the expressions, high cost and low cost.

SOME PRINCIPLES OF RESISTANCE FURNACE DESIGN.

A very long and very useful paper on this subject was presented by Mr. CLARENCE L. COLLENS, 2d, of Niagara Falls.

The discussion is restricted to intermittent resistor furnaces in which the net chemical reaction, if there is any, is endothermic, and in which the heat-generating body or resistor is separate and distinct from the materials to be acted upon. The flow of electricity is assumed to be limited to the resistor itself. The heat is assumed to be diffused principally by conduction.

If one constructs graphically the system of isothermal surfaces and that of the lines of flow of heat (perpendicular to the isothermals), one gets a concise picture of the heat diffusion within the furnace. The isothermal of highest temperature is somewhere within the resistor and is represented by some neutral point, line or surface, from which emanate the lines along which all the heat generated flows outward through the furnace.

The desired reaction or effect must usually be carried on between definite limits of temperature; the minimum temperature may be designated t_1 , the maximum temperature t_2 . (The minimum temperature t_1 is evidently the temperature at which the desired chemical reaction starts. The maximum temperature t_2 is somewhat arbitrary.)

Those particles of the material under treatment which are next to the resistor are at the highest temperature. The surface separating the resistor and the material under treatment is called the "surface of productive heat-diffusion." Going further outwards, away from the resistor, the temperature gradually decreases until we come to an isothermal surface at which the temperature is just the minimum temperature t_1 required for the reaction. This surface is called "the surface of non-productive heat diffusion," because any heat passing through this surface to the outside is wasted, since the temperature beyond this zone is no longer sufficient to produce the desired reaction. The change of the raw material *M* into the desired product *P*, therefore, goes on within the zone between the surface of productive heat diffusion and the surface of non-productive heat diffusion.

The second part of Mr. Collens' paper deals with an analysis of energy consumption within the furnace. Energy is first consumed to heat (to t_1) and superheat the resistor. The total balance of energy consumed passes through the surface of productive heat diffusion into the charge material *M*, and is consumed there in four different ways: (1) To heat the material *M* to the temperature t_1 at which the reaction starts; (2) to produce the chemical conversion of the raw material *M* into the product *P* at the temperature t_1 ; (3) to superheat the product *P* next to the resistor; (4) to heat the material *M* beyond the area of non-productive heat diffusion. This fourth part of energy is wasted in so far as it does not serve to change the material *M* into the product *P*. In Mr. Collens' paper the analytical expressions are given for the different amounts of energy as above defined. The formulas look quite complicated, since it is necessary—even for the most fundamental expressions—to make free use of the calculus.

The third part of Mr. Collens' paper gives a mathematical discussion of the rate of temperature change. In intermittent resistor furnaces we have not a steady stationary flow of heat, but the temperature of each part is continually more or less changing. The temperature changes with the distance (x) away from the surface of productive heat diffusion, and, if the fixed stationary state is not reached during the entire run, it also varies with the time or length of run; hence the temperature t at any point is a function of both the distance x and the time. The author's analysis shows that the rate of temperature change with respect to the time is greater the higher the specific thermal conductivity of the materials, the lower their density, the lower their capacity for heat, the greater the rate of change of the rate of change of the temperature between successive points, and the less divergent the lines of flow of heat.

In actual practice the general shape of the isothermal surfaces after a given interval of time can usually be determined very accurately by certain definite indications within the materials under treatment, such as the point where a reaction commences or ceases, the formation or decomposition of a carbide, the point where a deposit occurs or some material vaporized in the hotter regions of the furnace, certain gradations in the color of the materials formed, etc. A white deposit may even be formed in some cases, about $\frac{1}{4}$ inch in thickness, which, in cutting away the materials after a run and exposing a cross-section of the furnace, gives an indication of the shape of that particular isothermal just as distinctly as if a chalk line had been drawn around the resistor.

Invariably with a rectangular granular resistor the indications of the furnace show that as time elapses the isothermals gradually become rounded surfaces of circular cross-section. This is a striking example of one result of the author's analysis. For when starting the furnace, the isothermal surfaces next the resistor must have similar or rectangular cross-section. That means, at the corners, the lines of flow of heat are

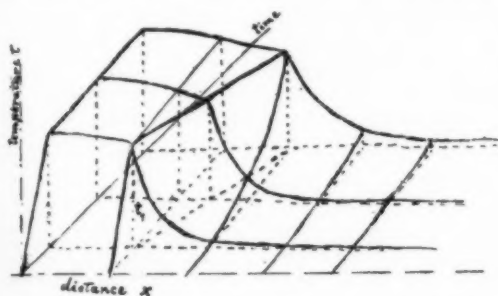


FIG. 4.—GRAPHICAL REPRESENTATION OF THE FLOW OF HEAT IN A RESISTANCE FURNACE.

more diverging than at the sides. Hence, according to the above theory, the rate of temperature change with the time is slower at the corners than at the sides. This necessarily rounds up the corners of the isothermals.

The conditions of a single-resistor furnace are shown in the diagram of Fig. 4. Here we have three rectangular co-ordinate axes, one representing the distance x measured along a line of flow of heat, the second the temperature t , and the third the time. The figure shows a uniform advance of the isothermal surface t with the time, although this condition does not necessarily exist. A plane drawn parallel to the temperature and time axes at any value of x cuts from the temperature surface a curve representing the increase in temperature of the point x with the time. Similarly a plane drawn parallel to the $o t$ and $o x$ axes, cuts from the surface a curve showing the temperature drop along the line of flow of heat after a certain time has elapsed.

In the fourth part of his paper, Mr. Collens discusses the

rate of energy supply per unit of surface of productive heat diffusion. He shows that a high value of this rate results in a high thermal efficiency, as far as the heating of the materials is concerned. A high value of the rate of energy supply, and consequently a rapid advance for the isothermal surface t , tends to maintain a steep slope for the temperature curve just outside the isothermal surface t with a flatter curve beyond. This condition gives very efficient heating in the zone between.

But this thermal efficiency should not be confused with the commercial efficiency of furnaces of this type, for in actual practice a maximum economical limit is often placed upon the rate of energy supply by other items effecting the total costs. Thus, if there is only a very small margin between the maxi-

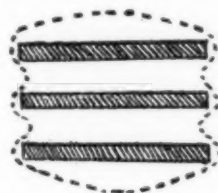


FIG. 5.—ISOTHERMAL WITH THREE-RESISTOR FURNACE.

mum and minimum temperature limits of a given operation, a high rate of energy supply means a very small thickness of product formed for the same cost of loading the furnace as if the rate of energy supply had been smaller and the thickness formed greater. Or, in certain cases, a time element may be necessary for the reaction in question, precluding too rapid rates of energy supply. But in spite of these limitations the importance of the rate of energy supply must not be minimized.

In some cases the commercial efficiency may be increased 25 per cent by doubling the rate of energy supply.

The author sums up his general considerations in the following four principles:

1. Increase as far as possible the ratio that the surface of productive heat diffusion bears to the surface of non-productive heat diffusion.
2. Increase up to the economical commercial limit the rate of energy supply per unit of surface of productive heat diffusion.
3. Avoid as far as possible in the furnace design, shapes or conditions which give lines of flow of heat which are widely diverging.
4. Surround the productive zone of the furnace with materials which are as refractory as possible, both as regards thermal conductivity and thermal capacity, and which will still withstand the conditions to which they are exposed.

In actual practice these principles are already being utilized to a large extent, especially the first. Take, for instance, the multiple resistor furnace (Acheson, siloxicon, our Vol. I., p. 287) and furnace types in which the resistor is zigzagged through the materials from one furnace terminal to the other, such as Tone's silicon furnace (our Vol. II., p. 111) and a recent compartment furnace of Fitzgerald and Bennie (our Vol. III., p. 346). In all these cases the saving effected is due to an increase in the surface of productive heat diffusion within a given surface of non-productive heat diffusion. As an example of the saving effected by multiple resistors a cross-section of a three-resistor furnace is shown in Fig. 5. On a certain class of work with 10 inches of product formed between resistors only three or four would be found on the top and bottom, the isothermal t assuming the shape shown by the dotted line.

The above four general requirements may be summed up in one fundamental principle of intermittent resistor-furnace design: "inside the advancing isothermal surface t , or zone of work, approach as near as possible, and outside avoid as much as possible the state of steady flow of heat and fixed temperatures."

The concluding part of Mr. Collens' paper deals with applications of the above principles to some types of commercial resistor furnaces. The carborundum furnace is discussed at great length, and it is pointed out that the principal

factor which enters into the determination of the most efficient size of carborundum furnace is the rate of energy supplied per unit of surface of productive heat diffusion.

If the radius of the resistor is increased its volume is increased in greater proportion than the surface of productive heat diffusion, which means that the energy required to heat the resistor itself will be greater per unit of product manufactured. With the radius of the resistor increased, the lines of flow of heat from the surface of productive heat diffusion become less diverging, which is a slight advantage, but this is more than offset by the smaller rate of energy supply, and consequently lower thermal efficiency. If the radius of the resistor is decreased, the rate of energy supply per unit of surface of productive heat diffusion is increased, resulting in greater thermal efficiency. But at some point a maximum economical limit is reached. Thus if the surface of productive heat diffusion is halved, the rate of energy supply is doubled, which means that with definite maximum and minimum temperature limits the product can be formed to only one-half the thickness.

Hence we have only one-fourth the previous amount of product formed in practically one-fourth the time, and although the smaller amount is manufactured at a higher thermal efficiency, or power cost, the labor cost of loading and unloading the furnace and other fixed charges may not have decreased in the same proportion as the output of the furnace. Furthermore, as the size of the furnace is decreased the loss in the furnace heads becomes a larger factor in the total costs. Thus we have the two extremes, and by proper elimination the economical intermediate point is determined. Even for each size of resistor, however, there is a definite length of run giving the maximum efficiency, so the problem is not quite as simple as it appears at first sight.

The formulas given in the former parts of the paper are then applied by Mr. Collens to the carborundum furnace, and the heat diffusion as well as the different factors of energy consumption are discussed both mathematically and graphically.

In the Acheson siloxicon furnace a very low rate of energy must be used on account of the narrow temperature limits of the reaction. To counterbalance the low thermal efficiency which would follow from the low rate of energy supply a multiple-resistor design is used. But it is very probable that the low rate of energy supply more than offsets the high ratio that the surface of productive heat diffusion bears to the surface of non-productive heat diffusion, and that consequently the manufacture of siloxicon is carried on with less thermal efficiency than the manufacture of carborundum, on account of the characteristics of the two materials.

In the Acheson graphite furnace the surface of productive heat diffusion is infinitely large as compared with the surface of non-productive heat diffusion. As the only maximum temperature limit, if any, is that at which carbon vaporizes, a very high rate of energy supply may be used. Furthermore, the surface of non-productive heat diffusion may be surrounded by the most refractory materials which it is possible to obtain. Hence very much higher thermal efficiencies are possible in the manufacture of graphite than in the manufacture of carborundum or siloxicon. In the Acheson furnace for graphitizing electrodes the conditions are similar, and very high thermal efficiencies are possible.

In the Castner process for graphitizing electrodes, the current is passed lengthwise through a single electrode connected to the two furnace terminals. Theoretically such a method is more efficient thermally than the Acheson process. The surface of productive heat diffusion is infinite, being the surface of the molecules, and the rate of energy supply can be made exceedingly high. But commercially the Castner process cannot compete with the Acheson process, as the labor costs are much higher. Furthermore, the loss of heat through the furnace terminals in the Castner process is excessive. These

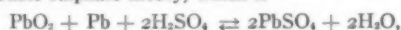
must inherently be very much larger in cross-section than the carbon under treatment, and are made of material which is a good thermal conductor.

The Acheson process for polymerizing carbons is thermally the same in principle and design as the graphitizing process, and is as efficient. In Hall's process for baking carbon electrodes the articles are placed at one side of a granular carbon resistor, and are separated therefrom by a definite thickness of a material which is a poor thermal conductor. The articles are also embedded in similar materials. Mr. Collens thinks that, obviously, such a process cannot be as efficient thermally as the Acheson process.

The paper of Mr. Collens was discussed by Messrs. Bancroft, Richards, Burgess and Hering. Prof. Burgess spoke of the paper in very complimentary terms, while Mr. Hering asked for commercial figures and dimensions, in general for such data as are needed by designers. He also referred to the design of the terminals. Mr. Collens replied that the effect of terminals cannot be easily given; it is the more important the shorter the furnace. If the current passes not only through the resistor, but also through the material under treatment, this is no disadvantage for the thermal efficiency of the process, since heat is then also produced directly at those places where the chemical reaction takes place. While the above abstract gives the full argument of Mr. Collens' paper, the reader must be referred, with respect to the mathematical formulas, to the full paper, which will be printed in the Transactions of the Society.

ELECTROLYTE DENSITY IN STORAGE CELLS.

A paper by Mr. LAMAR LYNDON, of New York City, was then presented, in the absence of the author, by Prof. Bancroft. The author refers in the introduction to the accepted reaction of the double sulphate theory, which is



the reaction going from left to right during discharge and from right to left during charge. When measurements of the density of the electrolyte between the plates were made in actual practice, it was found, however, that the higher the rate of discharge the less was apparently the abstraction of S and O from the electrolyte and the smaller the diminution of the density. Also with a given rate of discharge the change in density was apparently less toward the end of discharge than in the beginning.

This is not necessarily a contradiction of the validity of the above formula, since it leaves out of consideration the retarded diffusion of the electrolyte into the pores of the plates when the surface layer of active material has become practically sulphated, and thereby closes the pores in the surface of the plate. For this reason the electrolyte within the pores becomes more dilute than outside during discharge. If a cell is discharged at various rates and then allowed to stand discharged for several hours, the density of the electrolyte gradually falls (on account of diffusion into the plates), and in every instance approaches nearly to the value calculated from the above formula.

A plate, the active material of which is thin and porous, can be worked with an electrolyte of lower density than can one which has a thicker layer. Also in cells which are subjected to rapid discharges, the electrolyte density should be greater than in cells which are slowly and moderately discharged. The required density is, therefore, in a measure independent of the total quantity of electrolyte in cells having thick plates and subjected to rapid discharges, the active quantity being partly fixed by the amount of absorption in the pores of the plates.

High electrolyte density is therefore advantageous. It is also advantageous because the e. m. f. is higher. Very important factors, however, modify this deduction and fix the proper electrolyte density between 1.200 and 1.300 specific

gravity; *i. e.*, between 27 and 39 per cent of H_2SO_4 . The author gave experimental results, showing that the maximum capacity is obtained with thicker plates at a higher density of the electrolyte, which is in agreement with his previous deductions.

If the density of the electrolyte is then still further increased the capacity falls off. This is partly due to a minimum of conductivity of H_2SO_4 at 1.224 specific gravity, as has been pointed out by Dolezalek. But Mr. Lyndon points out that the rate of diffusion must also be taken into account, and that this varies with the depth and porosity of the active material and with the rate of discharge.

As a rule, the higher the discharge rate and the thicker the layer of active material, the higher must be the acid density for minimum capacity and efficiency. The proper theoretical density for any cell is that which will most nearly average 1.224 throughout its range of variation in concentration within the pores, and manifestly each particular make of cell has its own best density for a given duty, which can be determined only by experiment. The factors of durability and length of time between successive charges must also be taken into account.

Mr. Lyndon then gives a formula for computing the quantity of electrolyte required. If *S*, the ampere-hours of discharge; *X*, the ounces avoirdupois of electrolyte required; *D*, the percentage of the electrolyte H_2SO_4 at the beginning of the discharge, and *d* the percentage at the end of discharge, then *X* may be found from

$$X = \frac{S (0.129 - 0.1053d)}{D - d}$$

The paper is concluded by the following table, which gives averages of general practice in this country:

Kind of Plates	Character of Service	Discharge Rate in Hrs.	Density		Lbs. Electrolyte per 100 Amp.Hrs.
			Initial.	Terminal	
Pasted positive and negative	Motor car propulsion	4	1.300	1.100	22
Plated positive	General use	8	1.210	1.187	22
Pasted negative	small sizes	1	1.210	1.177	15
Plated positive	General use	8	1.200	1.180	25
Pasted negative	large sizes	1	1.200	1.165	15
Plated positive and negative	General use	8			
Plated negative	small sizes	1			
Plated positive and negative	General use	8			
Plated negative	large sizes	1			

ELECTROLYTIC CORROSION OF STRUCTURAL STEEL.

In continuation of his former paper, presented at the Bethlehem meeting, Dr. MAXIMILIAN TOCH, of New York City, the distinguished expert on paints, presented a further account of researches made by him on the important engineering problem of the electrolytic corrosion of structural steel.

Engineers have commented publicly on the electrolytic corrosion of structural steel, particularly those parts known as "grillage beams," supporting columns and base posts, which are either in the ground or surrounded by concrete and partly above the ground, with a view to determine beyond question at which of the poles corrosion occurs, and whether one pole is more active than the other. A series of experiments were started by Dr. Toch since the Bethlehem meeting, and definite results have been obtained.

The first experiment was performed, as in Fig. 6, by taking two sheets of high-grade watch-spring steel, which is extremely susceptible to corrosion, and connecting them with the ordinary bluestone telegraphic cell. A Pignolet combined volt and ammeter was placed in the circuit, and the two pieces of steel buried up to 5 inches in sand. The voltage was 0.05, the current varied from 0.02 to 0.05 amp., and the distance between the plates in the damp sand was $1\frac{1}{2}$ inches. Careful observation was made every day to see that the current was uniform, and the sand was first moistened with salt water and then continually moistened with distilled water, so that the same strength of salt solution was maintained. This experiment was conducted for 100 days, and assuming that the current

travels from plus to minus, or from anode to cathode, the anode being connected with the copper and the cathode being connected with the zinc, corrosion was noticed almost immediately at the anode, and the plates showed violent corrosion at the anode and practically no corrosion at the cathode. The



FIG. 6.—ARRANGEMENT OF EXPERIMENT.

plates indicated some slight corrosion on the cathode, which, however, was principally chemical corrosion.

The next experiment was tried exactly in the same manner—for a shorter period of time, but instead of using two plates three plates were used, the third one being designated as the "free" plate, in which chemical corrosion had full sway. It was not connected by any wire to the electric circuit. At the end of six days these plates were removed; the anode, as shown in Fig. 7, showed marked corrosion, the cathode plate showing practically no corrosion at all, and the "free" plate showed a fair average between the cathode and the anode, and it can be deduced that the difference between the cathode and the anode corrosion is equal to the "free" corrosion. In other words, there is many times more corrosion on the anode than there is on the "free" plate, and no corrosion on the cathode plate.

The plates were very carefully varnished all over to preserve them after the experiments were completed. The rust produced was first the green ferrous oxide, $Fe(OH)_2$, which, being a very unstable product, was quickly converted in the air into $Fe_2O_3(H_2O)$.

The voltage was 0.1 of and the current 0.1 of an ampere. The salt solution was four times as strong as that produced in the first experiment.

The third experiment shown in Fig. 8 was, however, of the greatest importance, owing to the fact that the author attempted to imitate the conditions exactly as they existed in



FIG. 7.—APPEARANCE OF THE THREE PLATES.

buildings. The same kind of steel was taken and bedded in various mixtures of concrete, starting from neat cement and going up to 1, 3, 5.

There is a well-known law in physical chemistry that reactions which take place with an increase of pressure are retarded by an increase of pressure, and the question has come up as to whether it is possible for steel to corrode when surrounded by concrete, many engineers holding that the alkaline nature of the cement will prevent the corrosion, and others

holding that in conjunction with this condition the pressure exerted by the concrete prevents chemical decomposition. Dr. Toch, in order to throw some light on this subject, made the following experiment:

In the first place, cement was taken of known composition, agreeing practically with the definition as quoted in the *Journal of American Chemical Society*, 1903, Vol. XXV., No. 7, July, when the question of the permanent protection of iron and steel by means of cement was thoroughly gone into. The cement for these experiments was what might be termed a tricalcic silicate and calcium aluminate. This is in contradistinction in the general classes of Portland cements containing dicalcium ferrite as a part of their composition and free calcium sulphate in excess. A cement of the calcium aluminate class, free from iron and free from calcium sulphate, is a well-known protector of steel and iron against corrosion, and this class of cement was used in these experiments. The pieces of steel were connected up with six elementary cells of

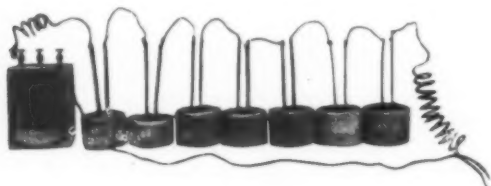


FIG. 8.—TESTING CORROSION OF STEEL.

sufficiently high voltage and amperage, and it was impossible to get a direct reading on the volt-ammeter, the instrument being too sensitive. The seven pats of cement containing the steel strips (see Fig. 8) were then put into the circuit and wet every few hours with solutions of 5 per cent sodium chloride and 1 per cent nitric acid and water, in order to increase their conductivity and produce corrosion as rapidly as possible.

The average voltage was 0.05 and the current 0.05 amp. throughout the entire experiment. Corrosion was immediately noticed on the anode pole, and the pat made of neat cement, which should have protected the steel most perfectly against all kinds of corrosion, showed a hair line split colored with rust at the end of the third day, which demonstrated that the chemical reaction of rusting had taken place at the anode; that the molecular increase had likewise taken place, and the pressure caused by the molecular increase had split the block.

The steel in each alternate pat was painted half the length, which was embedded in the cement with an insulating paint of known composition. The results obtained after these various briquettes were broken open, demonstrated that electrolytic corrosion takes place most violently at the anode unless the steel be coated with an insulating medium. Cement, concrete, or even neat cement, is, therefore, no protection against electrolytic corrosion unless the steel be insulated as heretofore mentioned. There was absolutely no corrosion where coated with insulating material. It must be noted that the cathode in all these experiments was perfectly free from any signs of oxidation.

The result of this entire series of experiments is to prove conclusively that electrolytic corrosion of structural steel embedded in concrete or sand takes place only at the anode, and there with great violence; and, furthermore, that the cathode is protected by the electrical current. The popular impression that cement is a protector against corrosion of all kinds is fallacious, and that the anode does not only rust very violently, but a molecular increase of volume may take place which will split the concrete shell.

Another conclusion arrived at is that the electrolytic rusting of grillage beams of buildings need not be feared if the structural steel be protected by a good insulating material, but the insulating medium should form a bond with concrete.

Dr. Toch's paper produced quite an animated discussion, in which Messrs. Acker, Bancroft, Hering, Palmer, Richards and Rodman participated. Mr. Rodman said that if steel is protected as cathode, then the steel structure of buildings should be artificially made a cathode. Mr. Hering referred to a means for this purpose, which consists in burying zinc in contact with the steel in the ground. This represents a short-circuited cell, in which the steel is the cathode; of course, the zinc is gradually consumed, but the steel is protected. The method is exactly the same as for the protection of boilers. Prof. Bancroft asked whether there was not with this method a possibility of a leakage of current from one steel cathode to another steel cathode, whereby the former one would, of course, be corroded. Mr. Acker spoke of a case in which he had been interested, of the destruction of gas and water pipes by the stray currents from an electric tramway system. The trouble was successfully overcome by improving the bonds between the rails and installing special return feeders, for the purpose of preventing stray currents from passing into the earth. Mr. Hering referred to the method which is usually employed in reports on the effects of stray currents from railways, and which consists in measuring the potential difference between rails and pipes; but it is not the potential difference but the ampere-hours which determine the amount of corrosion, and it is not proper to assume a large current with a large potential difference, since the conductivity of the ground is hereby entirely neglected. It is, therefore, not sufficient to measure the potential difference alone.

FUSED MAGNESIA OXIDE.

A paper by Prof. H. M. GOODWIN, of Massachusetts Institute of Technology, and Mr. R. D. MAILEY, dealt with the physical properties of fused magnesium oxide. They first describe the methods which they have used to fuse magnesia. The first attempt was made in a graphite-resistance furnace. A pure Acheson graphite rod, 18 inches long and $\frac{3}{4}$ inch outside diameter, was bored with a $\frac{1}{2}$ -inch drill, and the ends fixed into large graphite block terminals for leading in and out the current. The furnace was mounted vertically, packed with coke to prevent excessive oxidation of the graphite tube, and the whole heat insulated with firebrick. From 20 to 30 kw. were used in the furnace to maintain the temperature required. Chemically pure magnesium oxide was fed in at the top of the furnace in the form of a powder, and packed down by means of a graphite rod. In this way it could be melted, and rods of the fused oxide were obtained about $\frac{1}{4}$ inch in diameter and 2 inches long.

In no case, however, could rods be formed as large as the interior diameter of the bored graphite rod, owing to an action between the oxide and either the walls of the tube or gases given off from or diffusing through the walls of the enclosing tube. This was indicated by the formation of a volatile product, which condensed to a black mass in the upper cooler portions of the furnace. To prevent this substance from completely stopping up the furnace it was found necessary to bore lateral holes through the graphite tube in the hottest zone, at which condensation could not take place. The composition of the substance condensed in the cooler part of the furnace was not determined, although tests indicated that it was not a carbide. Treated with acid, hydrogen sulphide was always evolved, showing that impurities from without the furnace proper, probably in the coke, must have diffused through the graphite to the oxide within. The graphite rods were tested and found to be very pure, having been especially prepared for this work by the Acheson Graphite Co., of Niagara Falls.

As it was found that rods of magnesia of the desired size could not be obtained by the method above described (at least when carried out on the scale feasible at the time), it was thought that an arc furnace might be more effective. A hollow rectangular graphite boat, 10 x 4 x 4 cm., was used as a receptacle for the fused oxide. Over the center of this was

arranged a powerful alternating current arc, into which the oxide was fed from above. The whole was enclosed in graphite bricks, around which were built up fire-bricks. In this way irregular masses of the fused oxide, as large as one's hand, were obtained, and from such masses, rods or pieces of the desired length were bored by means of carborundum. The large masses thus obtained were not, however, homogeneous. Certain portions or layers were composed of very fine compact crystals resembling marble; other portions were composed of larger crystals. Some excellent samples were obtained, however, so hard and compact that they were quite non-porous to water and to fused salts. The great difficulty experienced was in getting pieces sufficiently free from tiny bubbles or blow holes. Up to the present time the authors have been unable to completely eliminate these in pieces larger than two or three cubic centimeters. If the process were to be carried out on a much larger scale and a larger mass of oxide brought to state of quiet fusion and then cooled, better results could undoubtedly be obtained.

In discussing the physical properties of fused magnesia the authors first mention its appearance, which is pure white and of a very hard crystalline structure. The fused surface resembles glazed porcelain.

The hardness is very high, and is between that of apatite (transparent variety) and feldspar (white cleavable variety), though nearer the former than the latter.

The specific gravity of three samples was found to be 3.485 at 19° C. and 3.562 and 3.493 at 20° C.

Determinations of the melting point show that it is between

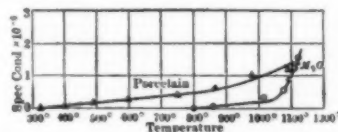


FIG. 9.—ELECTRIC CONDUCTIVITY OF MAGNESIA AND PORCELAIN.

1,890° and 1,940° C., so that in round numbers 1,920° C. may be taken as the approximate value. A more precise determination will be made in the near future by the authors.

The conductivity of fused magnesia was next determined, and may be seen from the following table, in which all the figures from 700° C. to 1,150° are the results of the authors' experiments, while the last figure, referring to 1,500° C., is taken from the Nernst-Reynolds-Landolt and Börnstein tables:

10° x Conductivity.	
800.....	0.01
900.....	0.10
1,000.....	0.20
1,050.....	0.34
1,100.....	1.00
1,150.....	2.60
1,500.....	85.00

[In the discussion which followed, Mr. Hering stated that the figures in this table were evidently given in meter-square millimeter reciprocal ohm units.]

Fig. 9 shows the change of the electric conductivity of fused magnesia compared with that of porcelain. Magnesia is a much better insulator than porcelain at temperatures below 1,100° C. Above that temperature the large temperature coefficient of magnesia indicates that its conductivity probably becomes greater than that of porcelain.

The measurements of the authors, which were made with direct current, indicated distinct polarization in the case of porcelain, but with magnesia no trace of such action was evident.

The last part of the paper of Goodwin and Mailey deals with their determination of the coefficient of expansion, and an

interesting result of their investigation is the close agreement which exists between the value of the expansion coefficient of fused magnesia and that of platinum. This should prove a valuable property in the construction of apparatus involving joints of these two materials. The authors have found that platinum caps, ground to fit the ends of rods of the fused magnesium oxide, remain tight over wide ranges of temperature.

The following chemical properties of fused magnesium oxide are interesting: The fused magnesia possesses in a remarkable degree the ability to withstand chemical action of many neutral salts at high temperatures, and is, therefore, well adapted for use as vessels and apparatus for containing such salts when subjected to high temperatures. Qualitative tests of the chemical action of various fused salts on the oxide gave the following results:

Silver, sodium and potassium nitrates, sodium and potassium chlorides, bromides and sulphates, zinc chloride and barium nitrate showed no action on a polished sample of the fused oxide, when the latter was heated for an hour or more in the fused salt. Barium chloride had a very slight action; sodium carbonate, potassium sodium carbonate, potassium hydrate, and cryolite attacked the fused oxide energetically.

Dilute hydrochloric, nitric and sulphuric acids attack the fused oxide in the cold slowly. Concentrated acids are less active than the dilute acids.

In a communicated discussion, Messrs. FitzGerald and Bennie, of Niagara Falls, pointed out that the properties of fused magnesia depend enormously on the purity of the material. In some tests of different samples of fused magnesia, taken from different parts of an electric furnace, the density was found by them to vary from 3.52 to 3.57. Since a small addition of impurities alters greatly the melting point, the conductivity and other physical properties, an exact analysis of the constitution of the material should always be given. Mr. Carl Hering objected to the use of the term specific conductivity by the authors, and urged that either the terms conductivity or specific conductance should be used. At 1,500° C. the resistivity of magnesia is about 700,000 times that of copper at ordinary temperature, while the resistivity of the Nernst lamp filament is about 400,000 times that of copper. He referred to a statement of Heraeus, according to whom porcelain at 1,600° C. conducts injuriously; *i. e.*, cannot be depended upon as an insulator. Prof. Bancroft referred to a case in which a resistance furnace had been built with porcelain as resistor; he also exhibited various magnesia articles made in Germany. Photographs of fused-magnesia articles made by Messrs. FitzGerald and Bennie were also shown.

CATHODIC DISINTEGRATION OF CARBON.

A paper on this subject by Mr. GEORGE I. KEMERER (which, like the next two papers, was a contribution from the University of Wisconsin, and was presented in abstract by Prof. C. F. Burgess), called attention to the fact that graphite is unattacked, and that other forms of carbon are fairly durable when used as anode material for the electrolysis of fused sodium chloride, but that it is apparently not so generally known that the same material when used as cathode is rapidly consumed. While appreciable corrosion occurs with Acheson graphite, it is less than 1 per cent of that which occurs on amorphous carbon. With amorphous carbon rods as cathodes in fused sodium chloride, the portion dipping into the electrolyte is completely disintegrated in from 1½ to 2 minutes. The author supposes that the liberated sodium unites chemically with the carbon, forming a sodium carbide, which would immediately break down at the high temperature used to keep the bath molten. The amount of disintegration was not proportional to the quantity of current, as would be indicated by the application of Faraday's law, but current density and temperature seem to exert an influence.

In the discussion which followed, Dr. J. Forssell, of the National Carbon Co., Cleveland, Ohio, pointed out that ordinary baked carbon rods consist of particles of carbon cemented together by a binding material; the latter would naturally break down under the treatment of the rod as cathode in a fused salt. Prof. Bancroft objected to the connection of Faraday's law with cathode corrosion; it is impossible to assume the formation of a definite compound; there may be the break-down of a solid solution.

A NEW SILICIDE OF MOLYBDENUM.

A paper by O. P. WATTS states that in 1893 only eleven compounds of silicon, with seven different metals, were known. The application of the electric furnace to this line of research resulted in a great extension of the list of metallic silicides, now thirty-two in number, and the end is not yet. A silicide of molybdenum, of the formula Mo_2Si_3 , has been known before. The author describes some experiments which make probable the existence of a silicide of molybdenum richer in silicon than Mo_2Si_3 , and probably having the formula MoSi_2 .

REDUCTION OF METALLIC SULPHIDES.

A paper by O. W. BROWN describes experiments in which the method of treating zinc sulphide with lime and carbon (see paper of Brown and Oesterle, our Vol. III., p. 378) is applied to the reduction of other metallic sulphides. The experiments were successful with the sulphide of molybdenum.

The sulphide of molybdenum, which is the principal source of this metal, is usually roasted until the sulphur is completely expelled and the impure oxide of molybdenum obtained. This oxide may be purified by the usual chemical methods and then reduced to metal by smelting with carbon in the electric furnace. If only a commercial metal is desired, the impure oxide, obtained by roasting the molybdenite, may be smelted with carbon without being purified. A considerable amount of molybdenum is lost during the roasting process, as the oxide is volatile at the temperature required to expel all of the sulphur.

The reduction of the comparatively non-volatile molybdenite directly to metal would save the cost of roasting, and prevent the loss of molybdenum which takes place during the roasting process. The author has found that molybdenite is easily and completely reduced to solid metal by electric smelting with lime and carbon, if the relative quantities of the material in the mixture correspond to those of the reaction



The largest amount of sulphur which was found in any of the samples of molybdenum made in this way was 0.25 per cent. For the complete reduction of molybdenite to metal, an excess of lime in the charge seems to be of advantage, while an excess of carbon leads to the formation of carbide, which holds back some of the molybdenum.

The author then tried to employ an analogous method for antimony. As metallic antimony boils at the comparatively low temperature of $1,100^\circ$ to $1,400^\circ$ C., it appeared that its sulphide ore could be reduced to metal and distilled in a manner analogous to that which may be used with zinc blende, but the experiments of the author show that the reduction and distillation of antimony from a charge of stibnite, lime and carbon is incomplete, even when the mixture is heated in an electric furnace to a very high temperature.

SODIUM PRODUCTION.

The last paper of the Monday session was presented by Mr. EDGAR A. ASHCROFT, the distinguished British electrometallurgist. The first part of the paper is a very interesting commercial review of the production of sodium, its present status and future possibilities.

The production of sodium metal, in the United States alone, is approximately 1,200 tons per year, whilst in England, and also in Germany, nearly similar amounts are produced. The disposal of this considerable quantity of metal takes place somewhere about as follows:

	Tons.
Used for cyanide making.....	1,500
Used for peroxide making.....	1,500
Sold as metal	500

Total of the world's production... 3,500

The figures, of course, are only approximate.

The price of the metal has gradually fallen during the last few years from 60 cents a pound, or thereabouts, to some 25 cents a pound, which is about the price to-day for large steady contracts.

The process due to the late Hamilton Young Castner has been in successful operation at Niagara Falls for many years. Many competitors have, however, arisen, and particularly, many attempts have been made to produce the metal by direct electrolysis of salt; but it is safe to say that none of these have, as yet, attained any substantial success, and, now that the older and successful process is becoming public property, through the expiring of patents, still less encouragement will be offered to possible competition in the future.

"In spite of these handicaps the author, like most inventors having a discursive kind of muse, has trayed into this field, and is now asking your kind attention to a brief account of a new method of production. Like a certain poor girl, when convicted of the crime of producing something which was not quite in line with the established order of things wanted, I feel inclined to plead in excuse, that the baby is 'only a little one.' I have, however, long felt that a genuine field for improvement exists in this growing industry, and my reasons are briefly as follows:"

Practically all the sodium at present made in the world is made by the Castner process, which consists in electrolyzing a pure form of caustic soda between electrodes of copper and nickel.

The costs of this process are known, and are, broadly, as follows, per pound of sodium produced:

Caustic soda	\$0.05
Power according to locality.....	0.01 to 0.05
Labor	0.025
Up-keep and standing charges....	0.02

Making a minimum possibility of cost under existing conditions of from 10.5 to 14.5 cents per pound. There are no by-products.

The new process of the author makes the metal by electrolyzing common salt in a fused state, by using a double electrolytic cell, in the first portion of which fused sodium chloride is electrolyzed with a molten lead cathode; an alloy of lead and sodium being formed, which is transferred to the second cell, where it is used as anode with an electrolyte of fused sodium hydroxide, yielding metallic sodium at the cathode. The sodium hydroxide is not consumed. [The first half of the process is, therefore, similar to that of Acker, the second to that of Castner.]

The cost of the Ashcroft process, when working on the same scale as the above estimate for the Castner process, is estimated as follows:

Common salt	\$0.005
Power according to locality.....	0.01 to 0.05
Labor	0.01
Up-keep and standing charges.....	0.025

Making a gross cost of 5 cents to 9 cents per pound of sodium produced, according to the cost of power.

In addition to this very substantial reduction in cost of manufacture, the new process produces a by-product of pure

chlorine gas which may be worked up by well-known methods into any of the numerous chlorine products, notably zinc chloride, bleaching powder, potassium chlorate, stannous chloride, sulphur chloride, carbon tetrachloride or chloroform. The value of this (if worked up into the heavier products like bleaching powder) is approximately $2\frac{3}{4}$ cents per pound of sodium (net after deducting cost of working up the bleaching powder). The value would be considerably greater if worked up into some of the other products named.

The power factor in each of the above two cases is practically identical, the Castner process requiring $4\frac{1}{2}$ total volts per cell and yielding 45 per cent real current efficiency, whilst the author's process requires 9 volts (7 and 2) per double cell, but yields twice the amount of metal (or 90 per cent real current efficiency) for a given current.

Mr. Ashcroft remarked here in parenthesis that "the low-current efficiency of the Castner process (a point, by the way, which has been often misstated) in comparison to the author's method (both delivering the sodium from caustic soda) is due to the chemical necessity which exists in Castner's method for decomposing an equivalent of water for every equivalent of sodium set free from caustic, a necessity which does not exist under the peculiar conditions of the electrolysis of caustic in the Ashcroft arrangement, as may be seen by a study of the reactions."

The commercial conditions (as to locality of works, etc.) for the two processes are practically identical, and great advantages are claimable by this industry for "cheap power" sites. The following table of Mr. Ashcroft shows the comparative cost of the several known means of producing power for such processes per horse-power years:

	Steam Engine Average	Gas Engine Average	Oil Engine Average	Niagara (Water) Average	Norwegian (Water) Actual
Cost of fuel			\$15.00		0
Labor and upkeep	\$40.00	\$30.00	2.75	\$20.00	\$2.50
Capital charges..			7.25		5.00
	\$40.00	\$30.00	\$25.00	\$20.00	\$7.50

Applying these figures of power cost to the manufacture of sodium, the result is approximately as follows per ton of metal produced:

Steam.	Gas.	Oil.	Water, Niagara.	Water, Norway.
\$120.00	\$90.00	\$75.00	\$60.00	\$22.50

But the question of transport is also important to the commercial issues, and the site of the works should be chosen with this also in view. The metal is at present transported in packages of 200 pounds weight. The package consists of a sealed metal drum, into which the sodium is packed in 5-pound cakes, taken direct from the producing plant. The peroxide is packed in 10-pound tins, placed inside a wooden box. The cyanide is also exported in sealed packages. The packages are returnable (except from very long distances), and in actual practice are found to last well, so that the entire cost of packing and transport has been now brought to a very low figure.

No special precautions are necessary beyond the exclusion of air and water. Although a few years ago sodium and its products would have been regarded as dangerous chemicals for transport purposes, the experience of the last few years has removed nearly all restrictions, and cheap freights now prevail in most countries. The author believes the rates of carriage in this country, moreover, are sufficiently low to minimize the economical necessity which exists in most other lands for getting right on the seaboard with all such factories.

Mr. Ashcroft concluded this section of the paper by a brief statement of some of the special reasons which lead him to hope for a large extension of the sodium industry in the future:

(a) The metal is produced from common salt, which can be obtained everywhere at a low cost as compared to any other metallic ores, and which contains no less than 40 per cent of the metal with scarcely any impurities or other contents except the combined chlorine (60 per cent). These conditions are unique and ideal from the metallurgist's point of view.

(b) The metal can be produced by the new process with an expenditure of no kind of material at all, except the salt (corresponding to the ore in other metallurgical operations) and a trifling amount of incidental stores. When producing on a large scale, almost the entire cost of production will be for electrical energy, and, given "cheap power" conditions, the cost of production by the new process may ultimately be brought very low indeed. These conditions are unique and ideal from the purely commercial point of view.

(c) With a reduction of price of sodium greatly extended, uses will be found for the metal, since very special physical, chemical and electrical properties attach to this metal unique properties. It is the lightest of all common metals, not excepting aluminium. It decomposes water freely by mere contact, producing a large volume of hydrogen gas and a by-product of caustic soda. This property suggests at once the use of water and sodium as balloon ballast for long journeys, so that when the ballast was to be discharged a simultaneous refreshment of the gas could be secured as well. It has the greatest energy of combination weight for weight with chlorine, oxygen, etc., of all the metals (excepting aluminium, which is an inherently much more expensive metal owing to the prevailing impurity of its ores and the difficulties of its reduction), and on this property reasonable hopes are founded that it will some day find extensive application as a medium (either secondary or primary) for batteries having the object of producing or conveying to a distance cheap electric energy. It reduces most oxides or salts of other metals setting free the metal, and it is reasonable to suppose that this property may insure its finding further extensive employment in metallurgical industries (particularly iron and steel production and purification, or in the chemical reduction of sulphide ores in remote localities), when it shall be produced in large quantities at prices that will satisfy economical conditions.

Sodium has, weight for weight, the greatest electrical conductivity of all the metals. The most promising future for sodium lies in the already extensive and rapidly growing gold-cyanide industry. Before the war in South Africa some 10,000 tons of cyanide were used yearly in gold extraction, and since the resumption of operations there, and with steadily extending growth of this form of gold extraction throughout the world, it is estimated that the world's consumption of cyanide has reached considerably larger figures; probably some 25,000 tons per year or more. Although much of this cyanide is manufactured by processes not employing metallic sodium as a base, it is well known that by far the best processes in use do so. Only the high ruling prices of metal sodium have limited the extension of these processes to the exclusion of all others, and a careful comparison of all known costs shows that whilst cyanide finds a ready market to-day at 16 to 18 cents per pound, but little profit remains to makers at this figure. The sodium employed being valued at 25 cents per pound, nearly all the profit is then on the sodium.

As an outlet for cheaper sodium, however, this case is very different. The conversion of metallic sodium into cyanide is possible in several different ways and is a cheap operation. For a works able and willing to market the metal at, say, 12 cents per pound, effective competition can be instituted with any existing process of cyanide manufacture.

The second part of Mr. Ashcroft's paper contains the technical description of his own process (the first of his American patents was abstracted in our Vol. III, p. 431). The patents were acquired in the early stages of the invention by the United Alkali Co., of Liverpool, and the process has been

worked first by the author and then out in detail by the staff of this company at their central laboratory at Widnes.

The apparatus illustrated in Figs. 10 to 16 comprises a composite cell, the two components of which are united by means of a "regenerator or heat equalizing device."

Salt is charged into a hopper *A* and fuses in the bath at *B*. The main current before passing into positive electrode *C* from the terminal, makes several circuits around the coil of conductor *E*, placed behind the lining *F* in the interior of the

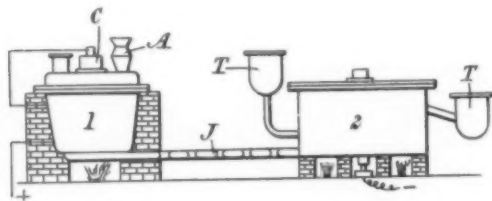


FIG. 10.—GENERAL ARRANGEMENT OF PLANT FOR PRODUCTION OF SODIUM.

decomposing cell 1, and thus sets up a strong magnetic field in the iron casing *C*, the lines of force tending to pass, as shown by the arrows, Fig. 12. The current crosses the electrolyte, decomposes the salt and then diffuses radially into the lead-sodium alloy *H*, forming the cathode on the bottom of the cell. The radial lines of current in the alloy cutting the lines of magnetic force nearly at right-angles, cause a motion of the metal in a plane again at right-angles. The direction of motion of alloy is indicated by the arrows, Fig. 14.

The effect of this is to maintain the liquid cathode and the electrolyte in circular motion, and as the rich alloy is formed immediately under the carbon anode, it is withdrawn from contact with the electrolyte by a skimming action on the surface of the lead, and passes into the division *I* of the composite pipe *J* through the holes *K*, the action being assisted if desired by small baffles *k* (Fig. 14). The adjustment of the magnetic exciting effect of the coil may be accomplished by varying the number of turns of the coil included in the main circuit, and for this purpose the several turns of the coil may be connected to a commutator or the like.

The main current, after entering the fused alloy (acting as cathode) in the decomposing cell 1, passes along the metal pipes *J* through the alloy (the pipe being preferably arranged

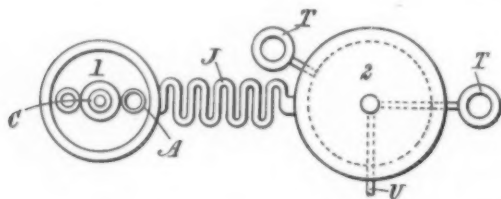


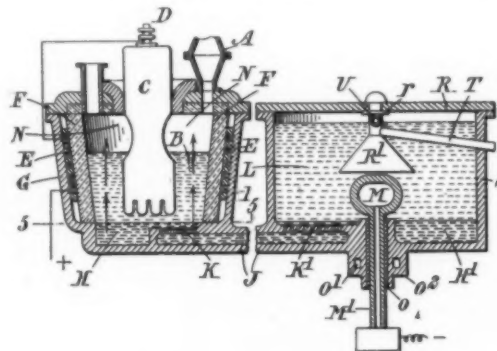
FIG. 11.—HORIZONTAL CROSS-SECTION.

as illustrated in zigzag form to secure large surface) to the second (or sodium producing) cell 2. Here the alloy acts as the anode *H'*, and the current traversing the electrolyte *L* (of caustic soda or the like) enters the cathode *M*, which is preferably of metallic nickel and of globular form, and is connected to a stem *M* of copper, preferably in tubular form, which passes through the bottom of the cell and serves to convey the current out of the bath. This cathode is insulated from the cell at *O* by an insulating sleeve (which may conveniently be composed of the chilled electrolyte), and through its tubular supporting stem a slight cooling effect may be obtained by air circulation (which can be further increased, at will, by circulating any suitable cooling liquid). This has the effect both

of aiding in solidifying the insulation in the sleeve *O*, and also slightly lowering the temperature of the bath at the actual point where the sodium is deposited, and thus minimising any reaction between the caustic soda and the sodium.

A similar device, to that described for the No. 1 cell, consisting of small holes *K*, Fig. 13, leading out of the composite pipe, and backed if desired by similar small baffles, ensures the delivery of the rich alloy at the surface of the bath of molten metal in this cell, and thus in the most active region for the desired removal of the sodium therefrom, and causes the alloy to circulate gently in the cell also. After circulating in this cell, the depleted lead, now more or less freed from sodium, is withdrawn by the motion of the metal into fine holes placed in the side of division *O* of the composite pipe *J*; thence it passes along the pipe and returns through similarly arranged small holes *P* (see Fig. 14) laterally into the decomposing or salt cell, thus completing the circulation.

The working temperature of the metal in the salt (or decomposing) cell, is approximately 700° C. when ordinary commercial salt is being decomposed. By means of the regenerative device shown, the alloy passing through the composite pipe *J* in opposite directions in the two divisions, transfers heat and thus tends continually to equalize the temperature of the adjacent passage at both ends. By this means the hot alloy leaving No. 1 (or decomposing) cell, heats the cold



FIGS. 12 AND 13.—VERTICAL CROSS-SECTION.

alloy arriving from the No. 2 (or producing) cell, and the cold alloy leaving the No. 2 cell cools the too hot alloy arriving from the No. 1 cell, so that the desired temperature is maintained in both cells without waste of heat.

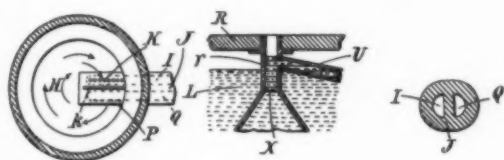
For the purpose of collecting the sodium deposited on the globular cathode *M* in No. 2 cell, the cell is preferably sealed from the air by cover *R*, and a funnel-shaped nickel screen *R*, terminating in a small pipe *r* of restricted sectional area is affixed to, and remains preferably to electrical contact with the cover *R*, and thus with the entire anode system of the cell. The effect of this somewhat unused arrangement is to preclude the possibility of sodium being set free in any part of the cell, except on the isolated globular cathode, from which it is immediately disengaged by gravity, and any sodium redissolved by anode at the point *X* will react with the caustic, according to the normal reaction 2NaOH (subjected to current) $= 2\text{Na} + \text{H}_2\text{O} + \text{O}$, and $2\text{Na} + \text{H}_2\text{O} + \text{O} = 2\text{NaOH}$ again, and not according to any of the reactions (such as $2\text{Na} + 2\text{NaOH} = \text{Na}_2\text{O} + \text{H}_2\text{O}$, etc.) which are found to take place when sodium metal remains long in contact with caustic soda.

Sodium is thus again set free at the cathode and normal caustic reformed at the anode, so that any leak-current has no detrimental effect on the composition of the electrolyte, and, furthermore, prevents direct chemical action. All the metal set free on the cathode, as already stated, immediately floats by gravitation to the surface and enters the restricted pipe *r*,

Being lighter than the caustic electrolyte its level rises, and it can thus be caused to leave the cell continuously as fast as formed, and collect in a suitable bath or receptacle by passing along a suitably placed pipe *U* (Figs. 13 and 15).

The restricted area of contact between the sodium and the caustic ensures that any possible corrosive action on the deposited sodium is reduced to a minimum, and the total efficiency of the cell thus increased to a maximum. This precise form of the above improvements relates to the fact that it has been found that the action of the sodium on caustic, when long exposed, tends to form oxides and sub-oxides, which reduce the efficiency of the caustic as an electrolyte. It may, therefore, sometimes be desirable to periodically renew the caustic by circulating it through pipes and reservoirs *T*. The caustic which has been long used in the cell and become inefficient, owing to solution of sub-oxides, etc., can be regenerated and brought into a useful condition again by merely exposing it to the air and allowing it to absorb water, or by treating it with steam, or by cooling and dissolving it in water and refusing.

The lining of the first (or decomposing) cell is of any desired material, such as magnesia bricks, which are found to withstand well the action of the electrolyte, alloys and other products, but even silicious or aluminous bricks (which are cheaper) are mostly found to be sufficiently durable. The heat of the cell may be supplied either from within (by the current) or from without by means of the gas jets or fire shown, or both expedients may be resorted to. The second (or producing) cell, when caustic is employed, may be conveniently regulated in temperature by a small supplementary gas flame, which can be adjusted at will. The rigid exclusion of air from the melted sodium is not so necessary when caustic soda



FIGS. 14, 15, 16.—DETAILS OF CONSTRUCTION.

is employed as secondary electrolyte, as it is with electrolytes fusing at higher temperatures, but it is, nevertheless, desirable to exclude air from the apparatus as much as possible.

Only those who have tried production of sodium by electrolysis of common salt—not on paper, but in factory-scale experiments, know how difficult a problem it is. In the first place, salt fuses at about 720°C ., and sodium vaporizes at nearly the same temperature. Therefore, such processes must collect two gaseous products, chlorine and metal, and the apparatus must be arranged so as to keep them religiously apart. But at this and even at much higher temperatures the vaporization of the sodium is far from rapid or complete. It floats about in great blobs on the surface and eagerly seeks every opportunity of meeting with its beloved chlorine. The real practical difficulty of avoiding all this and of simultaneously excluding all air is enormous.

These and other difficulties of a practical nature have never been effectually surmounted in spite of many paper processes and many immature patents; it would be rash, however, to predict that they never will. As sodium chloride is a true electrolyte, and one which does not react with metallic sodium detrimentally (the sub-chloride theory at one time advanced has been exploded) to any great extent, the tendency to work in this direction will probably continue. The nearest thing to success in the direction of electrolyzing salt was found in the work begun by Rogers, of Milwaukee, many years ago, and perfected by Acker recently for another purpose: that is the manufacture of lead-sodium direct from salt. The Acker pro-

cess (see our Vol. I., p. 54) has many points in common with the first half of the above described sodium process. But it does not go far enough for the production of metallic sodium.

Here the difficulty of practically dissociating sodium chlorides just disappears, for the sodium does not distil from the lead alloy at the melting point of salt, although it begins to distil at a point very slightly higher, and for that reason the temperature and other conditions require very careful adjustment. "The process I have described takes full advantage of the work of Rogers and of Acker and of other workers in the same field, and acknowledgements are due to these."

Another fortunate circumstance for the Ashcroft process is the lowering of the fusing point of lead by the just necessary 50° or so, which a slight alloy of sodium brings about, thus enabling the fluid alloy to be used in the second cell without overheating the caustic soda. As caustic soda appears to be the one electrolyte from which sodium can be quite comfortably collected in fluid form, even whilst exposed to the air, and as it is, moreover, essentially cheap, there is a decided practical advantage in using this material for the unchanged secondary electrolyte, in preference to any of the other possible salts of sodium which might be employed. A further point of incidental advantage gained in the sodium end of this process is the avoidance of any liberation of hydrogen. Not only is the current efficiency thereby doubled but the continuous, automatic collection of the sodium is rendered possible, owing to the absence of the continual fusillade of popping hydrogen explosions, which is inseparable from the Castner process.

The paper produced considerable discussion, in which Messrs. Acker, Carrier and Hering participated. All of them thought that the electromagnetic method of stirring would be very inefficient, and that some positive mechanical device would be more satisfactory. Mr. Acker also referred to impurities occurring in common salt, and to the formation of a crust on the molten lead cathode in the first cell, which would offer great difficulties. The second half of the apparatus seemed attractive to Mr. Acker, but he thought it would need to be much larger than shown in the figures on account of the lower temperature. Mr. Hering pointed out that the ampere-hour efficiency of both cells must be absolutely the same, otherwise it would be necessary to shunt one of the two cells. Mr. Carrier thought a great difficulty and a large loss of heat would be found in transferring the lead-sodium alloy from one furnace to the other furnace. If the crust on the lead alloy referred to by Mr. Acker should be formed, it would increase the voltage very much. Mr. Ashcroft, in his reply, said that the first cell (to which the chief objections had been made) had been in continuous satisfactory operation for three weeks on a large scale, and that all practical difficulties which had first been experienced had been overcome. As to the larger size of the second cell and the necessity of shunting one of the two cells, he agreed with the previous speakers. With respect to the alleged inefficiency of the electric magnetic stirring apparatus, he replied pointedly that the power required for this purpose was quite as negligible as the power which is required for raising a teaspoon or a glass of beer from the table to the mouth. The chief point is that it gets there; the electromagnetic stirring apparatus is extremely convenient and does the work well, while the cost of power for this purpose (measured in foot-pounds) is insignificant.

TUESDAY AFTERNOON.

On the afternoon of May 2 the chemical laboratory, the dynamo laboratory, the engineering laboratories and the shops of Cornell University were inspected. The excellent equipment of the laboratories was highly appreciated by the visitors, especially as quite a number of interesting experiments were in actual progress during the visit, including electrolytic deposition of chromium and the manufacture of carborundum and calcium carbide in an electric laboratory furnace, as well

as the electrolytic plant from which oxygen and hydrogen gases are supplied to the different laboratories. In the electrochemical lecture room, Prof. Bancroft described his new switchboard, which offers a possibility of getting any voltage and current at different parts of the table. He also showed some instructive electrochemical experiments.

THE ELECTROCHEMISTRY OF CHEMISTRY.

At the last meeting of the Society at Bethlehem, Dr. WILDER D. BANCROFT presented a lecture on the "Chemistry of Electrochemistry" (see our Vol. III., p. 370). His presidential address, presented on the evening of Tuesday, dealt with the reverse problem, namely, the electrochemistry of chemistry. He referred to the great assistance which electrolytic methods offer in chemical analysis, and then called attention in broad lines and in a most suggestive manner to the service which electrolytic methods may render in chemical researches when the same reaction can be produced in an electrolytic cell as in a chemical process.

At first it would seem that there is always a very distinct difference, since an electrochemical process always occurs at two distinct spots, the anode and the cathode, while a chemical process takes place uniformly within the reacting materials. But the difference is rather more apparent than real.

The author discussed a number of different reactions which "go" both chemically and electrochemically, and dwelt on such cases in which there is an apparent difference. In various cases he could show that an apparent discrepancy was simply due to the fact that the conditions of both cases were not exactly alike. He dwelt especially on the study of corrosion of metals, and emphasized a general rule, namely, that if a metal becomes passive as anode in a solution it cannot chemically rust in that solution. This rule, as far as applied, has always been found to be correct. Any solution in which the iron anode becomes passive does not produce rust. In sodium chloride solutions an iron anode does not become passive, hence iron will rust in this solution and the reaction velocity is normal.

In this way the corrosion of iron, steel and other alloys may be studied. The chemical study of corrosion is not an easy thing, since it would require weeks or months, and it would be extremely difficult to maintain the conditions constant. But since we can produce the same results by making the metal the anode in an electrolytic cell, we can finish the test in 8 hours instead of eight weeks. Of course, the results must be checked by analogous tests of chemical corrosion.

In passing over to the discussion of solution of bronzes, Prof. Bancroft referred to the statement that it is the less noble metal which will always dissolve. He said this is a very nice statement but it is not true. The whole argument in its favor is based on the measurement of electromotive forces. However, as soon as corrosion begins, the original system is changed.

It seems that the whole problem of preventing corrosion depends very largely on the question whether a protective film is formed; now this side of the question is actually lost sight of in electromotive force measurements. In general, electrolytic corrosion and chemical corrosion are identical. All the

exact evidence which we have points that way (see the paper of Curry abstracted below).

The electrolytic method has the advantages of convenience and reduction of time for the investigation of corrosion, but the rate of corrosion is, of course, different in both cases, and the results must be checked. At the conclusion of his address, Dr. Bancroft called attention to the use of the electric current in synthetic organic chemistry, where in recent years a large and promising field has been opened.

For details of the highly suggestive and interesting paper the reader must be referred to the full address, which will be printed in the "Transactions" of the Society.

After the address there was a most enjoyable reception at the Town and Gown Club. Refreshments were served in the upper rooms; the steins clinked freely and rival songs from the University Glee Club and from the table of the revived Free Ions held the company together until a very late hour.

WEDNESDAY SESSION.

LABORATORY RESISTANCE FURNACE.

The first paper of the Wednesday session was presented by Mr. G. R. WHITE, of Ithaca, N. Y., who described a simple and cheap laboratory furnace useful for the production of calcium carbide, carborundum, etc., where not too much power is available. Samples of calcium carbide and carborundum were exhibited. Two types of cores for the resistor were described, first a carbon rod and second a core of crushed pressed carbon packed around with graphite powder for the sake of protection. Strong packing and a long time of heating are required in this case. Both the rod and the crushed carbon used for the laboratory furnace shown had been supplied by the National Carbon Co. The chief advantage of the construction is that it is cheap and enables one to make instructive experiments.

In the brief discussion which followed, Prof. Bancroft referred to the distinct circular line of siloxicon which is seen around the carborundum formed in such furnaces when it is broken up.

ELECTROCHEMICAL PROCESSES AS STATION LOAD EQUALIZERS.

A paper on this subject was presented by Mr. ELMER A. SPERRY, of Cleveland, Ohio. He discussed the possibilities of cooperation of central station engineers and electrochemists. In a central station the peak load represents the investment, but since the peak load is only of very short duration the full equipment is utilized only for a few hours every day. This is what central station engineers call a poor load factor. The problem is to find uses for the electric current during the hours of light load, so as to improve the load factor, and the question suggests itself whether the current could be used for the manufacture of certain electrochemical products. During hours of light load central stations could easily afford to offer the power at a very low rate. As a matter of fact, central stations are now keen for business. Some times they want, however, the right to cut off the supply in an emergency case.

Mr. Sperry has made inquiries in several cities, and divides the central stations into three classes, according to the number of hours for which they would guarantee continuous current supply to electrochemical customers. Stations in the first class can supply current for 98 per cent of the whole year, those in the second class for 96.5 per cent, and those in the third class for 92.6 per cent.

From inquiries in different cities he has found that the rates which can be secured under such conditions may even be more favorable than from hydraulic plants. No transmission cost is, however, included in the prices, and it would be advantageous for a new electrochemical plant to locate right near the central station. Of course, such an arrangement would be specially suitable for truly intermittent electro-



WILDER D. BANCROFT.

chemical processes, and there are only a few of this kind. When no interruption is permissible storage batteries could be installed, but this would, of course, increase the investment.

In the discussion which followed, and in which Messrs. Ashcroft, Bancroft, Carrier, Howard, Richards and Sperry participated, it was first pointed out that the whole question is what are the rates that are offered by central stations. Mr. Carrier said that the best rate which could be obtained from the central station in Elmira, N. Y., was a little below 1 cent per kilowatt-hour. Mr. Sperry had been offered better rates, varying from 0.28 cent per kilowatt-hour up to 0.41 cent. There are no losses in conversion, and it should be noted that 0.31 cent per kilowatt-hour is \$20 per horse-power-year, which is about the price at Niagara. Dr. J. W. Richards stated that almost all electrolytic processes are essentially continuous, but some electrothermic processes are intermittent, and they could be utilized. For instance, if a carborundum furnace could be operated so that the run takes 18 hours, it could be operated during the 18 hours of light load of a station.

Mr. Howard, of Boston, called attention to the fact that the large power stations have exhaust steam which they may sell for evaporating purposes. This would be an advantage for certain electrolytic processes. Dr. Bancroft referred to the Remington salt plant, where electric power is generated for light and traction and the exhaust steam, mixed with a little live steam, is used for evaporation. Mr. Sperry said that in Cleveland exhaust steam is transmitted two blocks from the station to the Cleveland Salt Co.

ELECTRIC VACUUM FURNACE.

A very interesting paper on this subject was presented by Mr. W. C. ARSEM, Schenectady, N. Y., who pointed out that a resistance furnace capable of working with a vacuum has distinct advantages, since the vacuum is good for the protection of the resistor and the temperature available is limited only by the evaporation of carbon. There is no possibility of chemical action of gases. He described a furnace developed by him in the research laboratory of the General Electric Co. It was already briefly described in our Vol. III, p. 196. It consists of an air-tight chamber having a refractory crucible placed centrally on a graphite stand. This crucible contains the material to be treated. Surrounding the crucible is the resistor of graphite, which is brought into the form of a tubular helix by cutting a helical slit into it (see our Vol. III, p. 218). It is provided at both ends with suitable terminals for the current supply. Around the heating resistor is placed a radiation screen consisting of an annular graphite tube filled with graphite powder. It prevents losses of heat by radiation. The crucible containing the material to be heated is preferably made of graphite, but magnesia crucibles and thorium oxide crucibles may also be used. A mica window on top of the furnace enables the observer to see the reaction.

In the furnace of the author it is easy to reduce the pressure to fractions of 1 millimeter of mercury, if all joints are tight. Alternating current is used with a rheostat. The conductors which lead to the resistor are made hollow, for the purpose of circulating water through them so as to keep them cool. The whole vacuum chamber is also surrounded by a water jacket.

The estimation of the temperature is most convenient, since there is a fixed relation between energy supply and temperature. By using the melting points of copper and platinum as fixed points it is easy to get at once the constants of the temperature scale. The relation is

$$n \log (y - 20) = \log a + \log x$$

where y is the actual temperature, 20 is the temperature of the cooling water, x are the kilo-volt-amperes. Up to 2,000° C. calibration by means of this formula is sufficiently satisfactory.

The principal source of error is variation of voltage of the generator.

With the first type of furnace constructed it was found that the so-called Edison effect from the hot negative leg caused a considerable leakage of current from the crucible to the screen. This trouble was overcome later on by proper insulation of the screen and bottom supports.

It is now possible to reach with this furnace a temperature of 3,100° C., but in this case the life of the heater is very short, on account of evaporation of carbon; 2,700° C. appears to be the vaporizing point of carbon in the vacuum. With temperatures below 2,000° C. the life of the resistor is practically unlimited. The furnace may be used for purifying metals in powdered form by fusing in vacuo, for determining melting points for synthesis and many other applications. In the discussion which followed all the speakers agreed that the furnace would undoubtedly prove very useful for many research purposes, and the remark was made that disadvantages of the construction of the design were the small capacity of the furnace (the crucible containing only a fraction of a pound), and the necessity of waiting until the material solidifies before it can be removed from the furnace. This brought out the reply from Mr. Arsem that a much larger furnace is in course of construction and one which will alloy the casting of the melt.

ELECTROLYTIC CORROSION OF COPPER-TIN ALLOYS.

A paper by Mr. B. E. CURRY on this subject was remarkable in view of the enormous amount of experimental work which it must have required and in view of the experimental confirmation of Prof. Bancroft's general principles of electrochemical and chemical corrosion (see his address above). Mr. Curry first gave the equilibrium diagram for copper-tin alloys for temperature between 1,100° and 0° C., and for alloys containing from 100 per cent copper to 100 per cent tin. He then gave the results of his measurements of electrolytic corrosion in the following electrolytes: Sodium sulphate, sodium nitrate, sodium acetate, alkaline sodium tartrate, acidified ammonium oxalate and sodium chloride solutions. The electrolytic corrosion was determined for each solution, and a diagram plotted giving the current efficiency of corrosion as ordinate with the composition of the alloy as abscissa, the composition varying from pure copper to pure tin.

For a sodium sulphate solution the curve looks like this: the current efficiency is 100 per cent for pure copper; when tin is gradually added, the efficiency decreases very slowly until at a certain point there is a sudden large drop; with further increase of tin the efficiency continues to decrease slowly until in a certain region there is almost zero corrosion (the passive state); with further increase of tin the current efficiency rises again to about 100 per cent for pure tin.

The curves for all the solutions studied show at certain points sudden drops in the efficiency curves. These are sometimes coincident with the formation of a new phase but sometimes not.

With a sodium chloride solution the corrosion efficiency is practically 100 per cent throughout. That means that all the bronzes dissolve in the chlorides.

The passivity was found in all cases to be due to a film. The film was removed and analyzed for copper and tin. Quite some copper was found but the film consisted practically of tin oxide with a small amount of copper in it.

To check the results some parallel tests were made on chemical corrosion extending over fifteen days.

As Dr. Bancroft pointed out in the discussion, all the evidence that we have is in favor of a perfect parallelism between chemical and electrochemical corrosion. Prof. Miller referred to the sudden drop in the current efficiency which sometimes occurs by very slight changes. Dr. Bancroft said that this is due to the formation of a film of stannic oxide. This is the only reason he knows of.

CORROSION OF IRON BY ACIDS.

A paper by Prof. C. F. BURGESS, of the University of Wisconsin, and S. G. ENGLE, gives the results of a study made under a grant from the Carnegie Institution of Washington. The corroding mediums employed were normal solutions of sulphuric and hydrochloric acids. Distilled water and chemically pure acids being used. The solutions were kept at room temperature (about 22° C.), and during corrosion additions of acids were made to keep the solutions at a nearly constant content of free acid.

Fig. 17 shows the relative rate of corrosion of five different samples of iron for successive hours during the progress of the tests. The striking facts which are brought out in the curves are that electrolytic iron (made by the process described in our Vol. II, p. 183) in the condition which it possessed just as it was taken from the tanks, corroded at a far greater rate than did the other samples, about six times as rapidly as the cast iron, four times as rapidly as the steel, and nearly forty times as rapidly as the transformer iron. It is also shown that the heat treatment to which the electrolytic iron was subjected, conferred upon it the property of resisting corrosion to a great degree, the heated electrolytic iron dissolving at a hardly appreciable rate as compared with the samples which had been unheated.

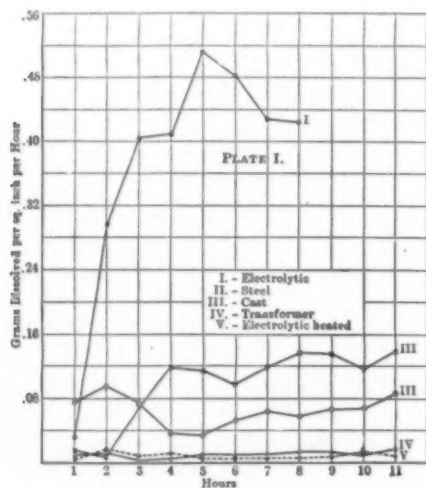


FIG. 17.—CORROSION OF IRON.

The rate at which an acid dissolves iron depends, of course, largely upon the elements with which the iron is associated. It is well known that the various metallographic constituents of iron and its alloys resist in differing degrees the attack of acids, and, consequently, different grades of iron show differences of durability.

The percentage of purity is, however, not the controlling factor, as is here shown by the observations that the heated and unheated specimens of electrolytic iron, essentially the same as far as chemical composition is concerned, exhibit the widest possible variations in rate of solution.

The crystalline or granular structure of iron seems to influence rates of corrosion in a marked degree.

The rapidity with which unheated electrolytic iron liberates hydrogen in a dilute acid solution suggests a useful application of this material in the production of pure hydrogen by replacing zinc, which is now commonly used. From equal surfaces of exposed metal, electrolytic iron liberates hydrogen about four times as rapidly as does pure zinc, and twice as rapidly as the commercial grade.

Another advantage in the use of electrolytic iron in hydrogen generation lies in its higher purity and the consequent

increased purity of the resulting gas, as compared with that which is obtained from zinc. One pound of iron produces 16 per cent more hydrogen than does 1 pound of zinc, and if a sufficient demand for iron for this purpose should arise, it could be supplied at a cost materially less than that of zinc.

Traces of arsenic are shown to exert such a marked influence in protecting iron from the corroding action of acids that the employment of this element for protection against ordinary corrosion appears worthy of further investigation.

While the measurement of electric potentials of iron against corroding agents seems to afford some indication as to the rapidity with which it will become attacked, it does not seem possible to establish definite relations between electric potentials and corrodibility.

In the discussion which followed it was suggested by Prof. Bancroft that to test the possibility of the protection of iron against corrosion by means of arsenic it would be necessary to produce a thin film rich in arsenic on the surface of the iron. Mr. Hering asked whether it is the hydrogen contained in electrolytic iron which gives it those special properties. Prof. Burgess replied that there is no exact proof. Mr. Arsem had heated electrolytic iron in vacuo, and it was then no longer brittle but had poor mechanical properties, due to the presence of oxide. He thinks that the oxide plays a greater part than the hydrogen. Mr. Little asked whether hydrogen made from iron would be more expensive than the electrolysis of water. Prof. Burgess replied that if the demand should be greater, electrolytic iron could be produced very cheaply. Mr. Rodman stated that to get hydrogen gas for some purposes, like lead burning, ordinary iron is now already used in connection with potassium permanganate.

DEVELOPMENT OF THE NICKEL PLATING INDUSTRY.

A paper by Mr. ISAAC ADAMS (well known as the "father of electroplating") gave a sketch of the development of the nickel-plating industry in the sixties, with some interesting and amusing personal reminiscences. The paper is concluded by the remark that the art is to-day carried on substantially as in 1869-70, with the same solutions, the same anodes and the same details of shop manipulation. This remark was resented in the discussion, but nothing was brought forward to disprove it.

Prof. Bancroft said that rolled anodes had formerly proven unsuccessful, but that there is a great opportunity of improving nickel-plating. In the solution now generally used nickel is passive, hence it would not corrode. For this reason it is now general practice to use cast nickel anodes containing 6 to 10 per cent of iron. This yields corrosion, but introduces other difficulties. Prof. Bancroft thinks that all our nickel-plating contains iron, and remarks that all the nickel plating on Weston instruments rusts red in the chemical laboratory. It is never safe to leave nickel-plated bicycles out over night. He, therefore, suggests to take a pure rolled nickel anode and to add a slight percentage of nickel chloride to the usual electrolyte. This yields corrosion, and results in pure nickel deposits. Prof. Burgess said that nickel-plating from a chloride solution is much softer, but Prof. Bancroft replied that he did not suggest the use of the chloride solution but only to add a little chloride to the electrolyte.

LEAD FROM ACETATE SOLUTIONS.

A brief note was presented by Mr. RALPH C. SNOWDON, the object being to show that it is quite possible to get a good plating deposit of lead even from an acetate solution, and that the favorable conditions are the same for lead as for other metals, although he does not recommend the lead acetate solution for commercial purposes. He used a cathode revolving at a speed of 2,500 r. p. m., and added 1 gram of gelatine per liter to a solution of lead acetate and acid, normal with re-

spect to each. The temperature was kept at 30° C., the cathode density was 1.5 amp. per square decimeter, and a lead anode was used. A matted deposit of lead was obtained, very adherent and entirely satisfactory in every way.

The discussion which followed related to the question of the underlying reason of the beneficial effect of an addition of gelatine, which has been found so useful on a commercial scale by Betts.

STRUCTURE OF ELECTRODEPOSITS.

A paper by Prof. C. F. BURGESS and Mr. O. P. WATTS was read by Prof. Burgess, who exhibited numerous lantern slides showing the structure of electrolytic iron deposits. The research was made in connection with an investigation of electrolytic iron under a grant from the Carnegie Institution at the University of Wisconsin.

The lantern slides exhibited illustrated numerous important factors which influence the physical structure of deposits. Thus lack of circulation may cause vertical grooving, due to the rising of dilute columns of electrolyte upwards. Gases dissolve in the electrolyte and give rise to pitting. It has often been believed that hydrogen bubbles are mostly responsible for this effect, but the authors have found that air is more troublesome. The pitting effect may be prevented by boiling the electrolyte and keeping air off. The combined pitting and grooving effect was also shown. Then the peculiar warts, sometimes appearing on deposits, were shown; these are growths perhaps due to little pieces of dust coated over. These growths are not merely a surface effect but extend inside. By a sharp blow of a hammer these warts (like teeth) may be detached from the plate, leaving cavities.

In the concluding part of the paper some analogies were pointed out between the structure of electrolytic deposits and the structure of certain geological deposits of hematite, magnetite and various other ores from solutions. This suggests a method of studying geological problems in the laboratory, since with the aid of the electric current the growth of a deposit may be investigated in a short time when the corresponding geological deposit in nature requires a very long time.

CADMIUM STANDARD CELL.

The Weston cadmium cell has become the pet standard cell in preference to the Clark cell for all ordinary laboratory work on account of the very low temperature coefficient of the former. It has repeatedly been suggested to authorize it as the fundamental primary standard.

Some six years ago Cohen, in Amsterdam, made a strong attack on the reliability of the cadmium cell as primary standard, but his arguments were exploded. Later on small troubles were still noticeable, but they were traced to the preparation of the mercurous sulphate, and it will be remembered that at the Washington meeting of the American Electrochemical Society an electrolytic method of preparing mercurous sulphate was described in two different independent papers, one by Dr. Wolff, of the Bureau of Standards, and the other one by Prof. Henry S. Carhart and Dr. Hulett (our Vol. II., pp. 174, 176, 407). It seemed at that time, and everybody hoped that all the difficulties with the cadmium cell had been overcome.

The paper which Dr. G. A. HULETT (Dr. Carhart's old co-worker in this field and now at Princeton University) presented at the Cornell meeting, contains a great deal of strict evidence to the effect that those hopes were premature. It should be emphasized here that Dr. Hulett's paper is quite conservative, and that he does not make any claim like Cohen six years ago. But since putting up the first cadmium cells with electrolytic mercurous sulphate with Prof. Carhart, he has continuously followed up this research, and produces in the paper a great deal of evidence showing a drifting of the

e. m. f. of the cadmium cell with the time. It is slight, but it exists. It is also evident from his research that the trouble is not with the mercurous sulphate, but must be with something else in the combination. It appears from his results that the cathode leg, as at present constructed, is not a system in equilibrium. While the cadmium cell will always remain an ideal secondary standard it, therefore, would seem that, at least, with its present construction it would be premature to adopt it as a primary standard.

The paper was discussed by Messrs. Bancroft, Miller and Patten. Prof. Miller suggested that the trouble might be due to a reaction of the glass used in the cells, but Dr. Hulett did not think so.

ELECTRODEPOSITION OF BRONZE.

A paper presented by Mr. B. E. CURRY dealt with the electrodeposition of bronze—the reverse problem of his corrosion experiments covered in the paper abstracted above. While chloride solutions give throughout almost perfect corrosion, it is impossible to get good electrodeposition of bronze from them. The best deposits were obtained from an ammonium oxalate solution slightly made acid with oxalic acid. The anodes were copper-tin alloys of varying composition.

The results of the author show that he was unable to get a good bronze deposit containing much less than, say, 80 per cent of copper. To get deposits containing less copper one needs solutions very low in copper, and the operation is easily thrown out of order. On the other hand, it is easy to get bronze deposits containing between 80 and 100 per cent of copper. This research, like that on corrosion, was made at Cornell University.

The paper was discussed by Profs. Bancroft and Miller. Prof. Bancroft pointed out that the deposition on the cathode was not the reverse process of the solution at the anode, since the corrosion of the anode depends on the anion while the cathodic precipitation depends on the positive metallic ions in the solution.

FERROMANGANESE ANODES IN ALKALINE SOLUTIONS.

The last paper of the Wednesday session was a brief note by Mr. G. R. WHITE, of Cornell. According to Lorenz, a ferromanganese anode dissolves as permanganate. Mr. White found the green manganate. This is always formed at 95°, due to a secondary reaction, namely, the reducing action of nascent hydrogen at the cathode. Any reduction to the green manganate at ordinary temperatures is due to organic acids in the solution.

WEDNESDAY AFTERNOON.

After the Wednesday morning session, as after the session of Tuesday, lunch was served by the courtesy of the University authorities in the Lecture Hall. Afterwards an excursion was made to the new Physical Laboratory (Rockefeller Hall) of the University, the splendid hydraulic laboratories, the power plant in the gorge and the works of the Ithaca Gun Co.

In the evening a subscription dinner was served in the Dutch Kitchen of the Ithaca Hotel, which was attended by some fifty members. The dinner was entirely informal and was very greatly enjoyed. Mr. H. B. Coho was a splendid toastmaster, and introduced the numerous speakers by pointed and witty remarks. Among the speakers were President W. D. Bancroft, who gave a review of the work of the Society during the last year; Prof. J. W. Richards, who emphasized the important progress now going on in the electro-metallurgy of iron and steel; Mr. E. A. Ashcroft, Mr. C. E. Acker, Prof. C. F. Burgess, Mr. Carl Hering, Mr. A. H. Cowles and Mr. C. E. Acheson. Mr. Acheson made a spirited speech, referring to the agitation now going on in the public

press in order to get legislation which would prevent the further use of the power of Niagara Falls for electric developments. He strongly emphasized that the general public alarm was unwarranted. Several of the speakers were introduced by little clever songs of the Mr. Dooley type, the alleged poets being Mr. H. B. Coho and Mr. H. T. Matthew.

After the banquet there was another informal reunion, with more singing, at "Zink's."

THURSDAY SESSION.

COLLOIDS.

The first paper of the Thursday session was presented by Dr. H. E. PATTEN, of the Bureau of Soils, of Washington, D. C., on the migration and flocculation of colloids, considered as an adsorption phenomenon. The problem interests the Bureau of Soils, since the getting of a soil into proper physical condition in all probability involves the coagulation phenomenon.

Dr. Patten discussed the problem briefly, and stated that the paper was more philosophical than experimental, and that the object was to get a working correlation of the facts involving as few hypotheses as possible.

He first referred to the fact that it is possible to get a charge of electricity on a diaphragm and one on the liquid simply by filtering the liquid through the diaphragm. The converse of this phenomenon is found in electrical endosmosis, where a charge on the diaphragm and an opposite one on the liquid produces mechanical motion, the liquid passing through the diaphragm. These two processes take place for very poorly conducting liquids, and hence in no way require for their explanation the assumption that ions exist in these liquids.

Secondly, where solutions of salts, such as potassium chloride, are filtered through soils, through finely powdered solids, through a coagulated colloid, or even through gelatine, the salt will be split up, the potassium is retained and the solution gives an acid reaction.

Thirdly, when we have a manifestation of electrolysis it always occurs at the boundaries. The action of these small particles of fine suspensions in liquid media in retaining acid or basic radicles selectively, is like the separation of the products of electrolysis at the electrodes. Where such a splitting of a salt takes place we would expect the particle of solid to acquire a charge of electricity, just as the electrode acquires it. And where an electrical pressure is placed upon the liquid containing such a particle, it would, of course, migrate under this difference of potential.

Fourthly, we have the fact that in general suspended particles migrate in acid solution towards the positive pole and in alkaline solutions toward the negative pole.

These different phenomena hold together, and this gives us a working correlation of the facts.

In the discussion which followed, Mr. Hering referred to the possibility of seeing the migration of the particles under the microscope, and Dr. Patten confirmed this with the restriction that this is possible if the particles are large enough.

FUSED SODIUM PEROXIDE FOR REGENERATION OF AIR

A paper by Messrs. GEORGE F. BRINDLEY and RICHARD VON FOREGGER was then presented in abstract, in the absence of the authors, by Mr. S. S. Sadtler.

In our April issue, page 128, we noticed, already briefly, a preliminary paper presented in March by Dr. von Foregger before the New York Section of the American Electrochemical Society, in which the speaker made some interesting suggestions on the purification of the atmosphere of the New York subway by means of oxone. The present paper gives a full report of the experiments of the two authors on the regeneration of air by oxone with special reference to use in submarine boats. (See also our May issue, p. 166.)

As has been repeatedly noticed in our columns (for instance,

our Vol. III., pp. 255 and 377), oxone is fused sodium peroxide, and when brought in contact with water it yields the reaction



The oxygen thus produced may be supplied to the lungs of living beings in a closed space, while the use of oxone has the further advantage that the carbon dioxide given out from the lungs is taken care of by the further reaction



For these reasons oxone is well adapted for the regeneration and purification of air, especially air that cannot be conveniently renewed by ventilation, and therefore has to be breathed over and over again. The object of the tests of the authors was to make this process entirely automatic, and their results show that it is quite possible to keep nine men alive in a submerged submarine for a period of 12 as well as 48 hours or more, probably within the full radius of action of such a vessel, depending merely upon the supply of oxone.

An average man requires 25 liters of oxygen per hour, and as 100 grams oxone furnish 13 liters of oxygen, 192.5 grams would give 25 liters. In other words, 1 kg. of oxone would sustain a man for 5 hours and 12 minutes, provided, of course, that he has to breathe the same air over and over again. These figures agree almost exactly with those obtained in the experiments of the authors.

Most of the experiments described by the authors were made with strong healthy rabbits, averaging in weight 7 pounds,

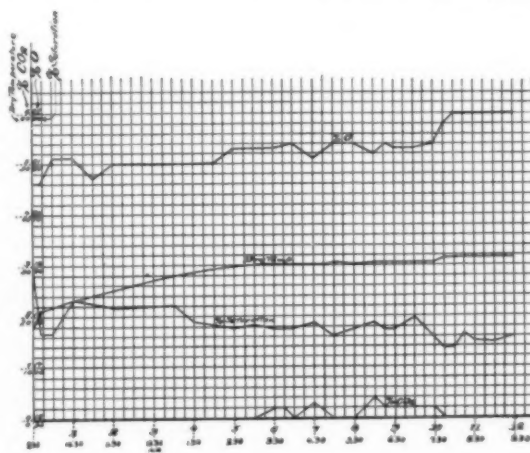


FIG. 18.—12-HOUR RUN WITH SIX RABBITS.

and although the weight of a single rabbit was only one-twentieth that of a man, the authors found that one man exhaled as much carbon dioxide as ten or twelve rabbits. The experiments were made in a strong wooden box, 3 x 3 x 6 feet, containing a plate glass window, which also served as an entrance, and which could be hermetically sealed. Inside the box was placed the apparatus, consisting of an electrically-driven blower, so arranged that its discharge was connected to a horizontal sheet-iron cylinder, in which was placed the oxone.

In addition to this was a cyclometer, an incandescent lamp, wet and dry bulb thermometers, and the necessary food for the rabbits. An Orsat apparatus was placed outside on top of the box, and connected with the inside by means of a glass tube. A wash bottle was also placed on top, and connection made with the inside. The wash bottle enabled the experimenters to introduce water if necessary, and the fluctuation of its water level when gas samples were taken indicated whether the box was air-tight or not.

In the first experiment of the authors they found that after the lapse of a certain time all reaction of the oxone ceased, owing to the formation of a crust of carbonate on the surface

of the oxone. This difficulty was successfully overcome by a mechanical agitator working the wire-netting cage which contained the oxone, and so arranged that the rate at which the cage was agitated could be regulated. The results were entirely satisfactory, and the device did not in any way interfere with the automatic nature of the process.

Of the numerous interesting diagrams given in the original paper we can reproduce only two on account of limitations of space. The first, shown in Fig. 18, represents the results of a run of 12 hours and 5 minutes, with six rabbits, $2\frac{1}{2}$ kg. of oxone being used. This was the first run with the agitating device. The barometer was 750 to 752 mm., the outside temperature 14.4° to 21.0° C. It will be noticed that at the end of the 12 hours the oxygen was slightly above normal, but steady at 22 per cent, and the CO_2 was down to zero. One-half of the original oxone still remained in the cage at the end of the experiment. The slight increase in oxygen in this case was accidental, and due to the falling of small pieces of oxone through the wire netting of the cage into the caustic paste accumulated in the outside cylinder, and there acting on the water, generating an excess of oxygen. The occasional appearance of CO_2 in this run was entirely due to the attempts of the experimenters to determine the slowest rate at which the cage could be agitated.

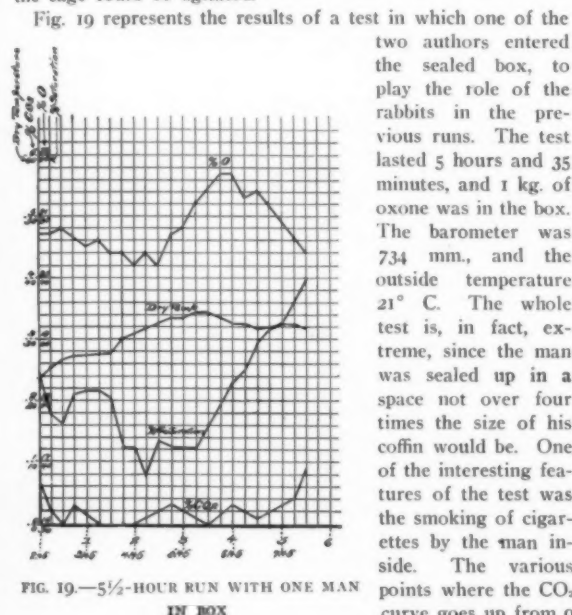


FIG. 19.— $5\frac{1}{2}$ -HOUR RUN WITH ONE MAN IN BOX

shows the times cigarettes were smoked. Another most noticeable thing was the absorption of the smoke and the drop of CO_2 to zero again within 15 minutes after the extinction of the cigarette. When the box was opened there was not the faintest smell of cigarette smoke. The man inside asserted that throughout the run he felt exceedingly well, in fact, better than before he entered. He described the conditions as being similar to a hot, dry summer's day.

The marked increase in humidity is in all probability due to the fact that for a few moments a wet towel was held in front of the fan inlet and 50 cc. of water placed in the bottom of the outside cylinder during the third hour's run. The presence of this water on the bottom of the outer cylinder was again a disadvantage, owing to small pieces of oxone falling into it and producing an increase in oxygen.

After $4\frac{1}{2}$ hours nearly all the oxone had gone, only a few small pieces remaining in the cage, and the oxygen started to go down.

How quickly the air becomes vitiated in such confined spaces is shown by the fact that during the short time it took to

get the man sealed up and the motor started, 0.6 per cent CO_2 had accumulated in the box. It will be noted, however, that within 30 minutes this was completely absorbed.

The final test of the authors shows curves (not reproduced here) of an exceedingly smooth and regular nature, since in this test the experience gained in previous runs was made use of.

In the conclusion of their paper the authors apply the results of their tests to the case of a submarine boat, the capacity of which is on an average 2,700 cubic feet, or 75,600 liters. With 9 kg. of oxone in all, nine men would be perfectly safe for fully 9 hours, and with 18 kg., or 40 pounds of oxone, they would be safe for at least 14 hours, so that if 40 pounds of oxone would supply nine men in a submarine boat for 14 hours, one man would require practically one-third of a pound.

In the discussion which followed, Mr. H. Howard, of the Merrimac Chemical Co., of Boston, Mass., referred to a case in which he had saved by means of oxygen the life of a man who had been overcome by inhaling gas. Respiration was restored by the use of oxygen generated from sodium peroxide and water. Mr. Ashcroft brought up a physiological question, and emphasized the great importance of the problem of regenerating air, while Mr. Carrier claimed that a catalytic agent is necessary to produce the desired reaction between fused sodium peroxide and water, and that such a catalytic agent is really contained in the fused sodium peroxide sold as oxone.

SWITCHBOARD.

The next paper on the programme, on a lecture-room switchboard, by Prof. WILDER D. BANCROFT, was taken as read, since Prof. Bancroft had already explained the switchboard when the members visited the laboratory.

ALTERNATING-CURRENT ELECTROLYSIS WITH CADMIUM ELECTRODES.

Mr. G. R. WHITE, of Cornell, then presented his paper on a special case of alternating-current electrolysis. When an alternating current is passed through a solution of sodium hydrosulphite with cadmium electrodes, a precipitate of cadmium sulphide is formed. This problem has been studied by Richards and Roepper, who have taken out a patent covering this phenomenon as a process for the manufacture of "cadmium yellow."

Le Blanc and Schick have also studied the problem, and have determined efficiencies with various frequencies; they found that at the higher frequencies the efficiency drops practically to nothing. The present author shows that their efficiency can be very much increased. The general results are that in spite of a better efficiency its value is still too low for a commercial process. The precipitate, moreover, is apt to be polluted with bits of the brown oxide film, which would be objectionable in a commercial product, and render special treatment for its removal necessary. The efficiency is practically independent of the current strength and also independent of temperature and of stirring. The efficiency depends almost entirely on the electrode surface, but in spite of attempts of the author to produce a uniform electrode surface the quantity dissolved varied widely.

The paper was discussed by Messrs. Miller, Patten, Bancroft and Richards. Prof. Bancroft pointed out that it will be impossible to trace exactly the influence of all other factors as long as it is not possible to make a reproducible electrode so as to fix the chief influence.

ELECTROLYTIC CHROMIUM.

A paper by Prof. MAX LE BLANC, of Karlsruhe, Germany, was presented in abstract by Mr. C. F. Carrier, Jr. It is mainly a reply to some criticisms of Le Blanc's work, con-

tained in papers by Carveth and Mott, and by Carveth and Curry (our Vol. III., pp. 176 and 273). The chief bone of contention is in regard to the patents of Placet and Bonnett, who stated that chromium could be electrolytically deposited in large quantities by electrolysis of a solution of chrome alum, to which had been added alkaline sulphates, plus sulphuric acid. Mr. Schick, working under Le Blanc, followed the patent specifications very closely, but could only get traces of chromium. Le Blanc concluded that a sample of chromium of 1 kg. weight exhibited by Placet to the French Academy of Science, was not obtained as stated, or that at least the essential condition of its production was omitted from the specification. It is to this conclusion that the above-mentioned gentlemen take special exception.

According to Prof. Le Blanc, the real question at issue is, "can chromium (of any desired thickness) be deposited from a solution of chrome alum in the way described by Placet and Bonnett?" This has not been answered by Carveth, Mott and Curry, for they did not work exactly according to Placet and Bonnett, and, moreover, their runs were so short that only a few milligrams of chromium were deposited.

Le Blanc has no doubt that chromium of any desired thickness will some day be deposited, and the work of Neumann and Glaser, supplemented by the three above-mentioned gentlemen, points in the right direction, but the problem is by no means solved. At least no precise data are available by which chromium can be deposited of any desired thickness.

Le Blanc then gives a review of extended work of Mr. A. Ruppert, who, at his request and under his supervision, endeavored to duplicate the work of Carveth and Mott. He discusses the best conditions for getting electrolytic chromium, the object being to obtain thick deposits on large scale. The best results were obtained with the following system; lead forming the positive pole, porous cup, chromium sulphate solution with an addition of boric acid, copper forming the negative pole; it was not rotated since the deposit was smooth without rotation, and since rotation seemed to have little effect on the efficiency. There was apparently rather a tendency to make it poorer on account of continuous removal of chromium sulphate from the surface of the negative plate.

Under these conditions the deposit was good at first, but cracks began to form as chromium became thicker, and finally tended to scale off.

The chief conclusions of the author are that thin deposits of fine quality of chromium can be plated on brass, copper, carbon; the thickest coat obtained was approximately 0.13 mm. Placet cannot have made his 1 kg. chunk of chromium which he presented to the French Academy in the way he claimed. This conclusion is reached from the character of the deposit.

In the discussion which followed, Dr. Carveth expressed his appreciation of the courtesy of Prof. Le Blanc to send his paper to the meeting at Cornell, where Carveth's own work had been done. While he will contribute a longer communicated discussion to the "Transactions" later on, he briefly stated that he had not considered that the production of any desired thickness was so very important, but he knew that his deposits were thicker than 0.13 mm. Prof. Bancroft suggested that Le Blanc should have used chromic acid as electrolyte. It works very well. Some samples of good deposits were exhibited. Prof. Bancroft said he could not believe that it is impossible to get deposits of any thickness. It is only necessary to maintain the original good conditions constant during the run (as pointed out by David H. Browne, our Vol. I., pp. 348 and 386), and this is quite possible with chromic acid.

Mr. Curry stated that they had made good deposits 1 mm. thick at Cornell. Mr. Carrier pointed out that there was a difference in the two problems which Le Blanc, on one side and the Cornell people on the other side, were endeavoring to solve; the former wants to make metallic chromium just as Burgess makes electrolytic iron, and, on the other hand, the latter try to get good electrolytic coatings for plating purposes.

FREE ENERGY OF VARIOUS COMPOUNDS.

A paper by Dr. M. DE K. THOMPSON, on the free energy of some halogen and oxygen compounds computed from the results of potential measurements, was then presented in abstract by Prof. Miller.

Dr. Thompson points out in the introduction that one of the most important chemical problems of the present time is the determination of the free energy of formation of compounds from their constituents, for it is this quantity and not the heat evolved that is the true measure of chemical affinity. No reaction can take place of itself that is not capable of doing external work, and the maximum amount of such work which a reaction can produce at constant temperature is called the free-energy-decrease of the reacting system. The author has computed this value for a number of compounds from potential measurements.

The chief results are contained in two tables, one of which gives the free and total energies of the solid halides of silver, mercury, copper, thallium and lead at about 18° C. Some interesting details of this chief table are still further condensed in the following summary of the free energies per equivalent of salt:

	Cl.	Br.	I.
Hg (ous).....	24,700	21,400	13,400
Ag	25,600	23,000	15,900
Cu (ous).....	28,100	23,700	16,600

This table means, for instance, that the free energy of Hg_2Cl_2 is 49,400. The table shows that the corresponding halides of mercurous mercury, silver and cuprous copper have free energies which differ from each other by less than 3,500 calories per equivalent, but which increase slightly in every case in the order mercury, silver and copper.

A second table contains the results for other compounds than halides, and is given below, requiring no explanation. It gives the free and total energies of the oxides of silver and mercury, of water, ammonia and hydrochloric acid at about 18° C.

Compound	Free Energy	Total Energy	Ratio of Free to Total Energy
Hg_2O	13,400	22,200	0.60
Ag_2O	3,900	5,900	0.66
H_2O (liq.).....	55,500	67,600	0.82
H_2O	53,800	57,500	0.93
HCl	22,300	22,200	1.01
NH_3	45,200	11,400	4.00

In the case of the solid salts investigated the ratio of the free to the total energy does not differ from unity by more than 7 per cent, except in the single instance of silver iodide. This result is of great practical importance, since it enables for approximate purposes the usually well-known heat of formation to be employed in the place of the often unknown free energy in the study of the equilibrium of reaction involving solid substances.

The paper was briefly discussed by Prof. J. W. Richards and Prof. Miller. Prof. Richards thought that the author laid too much stress on the importance of the free energy compared with that of the total energy. He also believed there was some hypothesis involved in calculating the free energy of the formation of water from the oxygen-hydrogen gas cell, the effect of the platinized platinum electrodes not being considered at all. Prof. Miller replied with respect to the relative importance of free energy and total energy that it all depends what one wants to calculate; if one wants to use the principle of conservation of energy, of course the total energy must be used; on the other hand, if one wants to know in which direction a reaction will go on or which one of several reactions will take place, the total energy does not give any exact information, and one has to refer to the free energy.

ELECTROLYSIS OF CAUSTIC SODA.

A paper presented by Prof. J. W. RICHARDS gave a useful and concise historical review of the various processes for electrolyzing caustic soda for the production of sodium, which have been either proposed or introduced into practice. Davy, in 1808, was the first to electrolyze caustic soda. Castner solved the industrial problem. The latter work of Rathenau, Becker, Carrier, Ashcroft, Scholl and others was discussed, and reference made to the research of Le Blanc and Brode as the best scientific investigation on the subject.

The paper was discussed by Messrs. Ashcroft, Carrier, Carveth, Forssell, Patten, Richards and Townsend. Dr. Forssell had once found globules of metallic sodium in a concentrated solution of caustic soda which he had electrolyzed the day before. In order to see whether these globules were protected by means of a thin coating he cut them into small pieces, but they did not react with the solution. Others had observed the same phenomenon. Dr. Richards confirmed Dr. Forssell's remark that sodium can be plated out from an aqueous solution.

One of the special results of the investigation of Le Blanc and Brode was the object of a remark of Mr. Carrier. They had found that at the anode hydrogen is really evolved together with oxygen, which sometimes results in explosions. Mr. Carrier used later the original apparatus of Le Blanc and Brode, and found that the above result was due to the construction of the apparatus, namely, to a bipolar effect of a screen. When the screen was removed the explosions stopped.

POTENTIAL DIFFERENCES IN AQUEOUS AND NON-AQUEOUS SOLUTIONS.

A paper by Prof. LOUIS KAHLENBERG, of the University of Wisconsin, and Mr. A. S. McDANIEL, was then presented in abstract by Dr. Patten. The object of their investigation was to measure the differences of potential developed between electrodes of lead peroxide and manganese peroxide and solutions in various non-aqueous solvents, and to compare these results with those found when water is substituted as solvent, all other factors remaining the same. Among the solutions studied were pyridine, acetone, amylamine, when free from water, and when containing water in various percentages. The Ostwald calomel electrode was used. The results are given in tables and diagrams, and for details the reader must be referred to the original paper.

The chief conclusion which the authors draw from their results is that the difference of potential between a peroxide electrode and the solution into which it dips is to be ascribed to the chemical affinity; *i. e.*, the chemical strain or potential between electrode and liquid.

The paper was briefly discussed by Messrs. Arsem, Hunter and Miller.

SILVER COULOMETER.

A paper on a new electrolyte for the silver coulometer (or voltameter) by Prof. HENRY S. CARHART, of the University of Michigan, and Dr. F. W. WILLARD, was presented in abstract by Mr. S. S. Sadtler.

The authors recommend silver perchlorate as electrolyte, and it is stated to eliminate the disadvantages of the nitrate. Silver nitrate is treated with perchloric acid and the nitric acid is driven off. A comparison was made between the use of earthenware diaphragms and filter paper, and the authors find that filter paper, as used by Dr. Guthe, is more satisfactory. The silver deposits have a very uniform appearance.

ERRORS IN PYROMETRY.

The last paper of the session was on errors in pyrometry, Mr. E. S. SHEPHERD, of Washington, being the author. In the absence of the author it was presented in abstract by Prof. Bancroft.

After some notes on errors in the use of Seger cones and carelessness in handling thermocouples, the author expresses his belief that chemists are too apt to think a pyrometer can be used in the same haphazard fashion as a simple mercury thermometer. As much as an error of 150° C. may be introduced simply by contamination of the thermoelement. Further, the galvanometer needle may stick. Then it is very important that the cold junction of the thermoelement is kept at constant temperature. (In the way in which some people use thermo-electric pyrometers the temperature of the cold junction sometimes varies by 1° to 20° from that for which the instrument was calibrated.)

The thermoelement and the material which is investigated must be in very intimate contact. The temperature at various places of an ordinary platinum furnace is apt to vary from 10° to 50° in different parts of the furnace, and in a gas furnace the variation is even greater.

All metals have an appreciable vapor tension, and this vapor attacks the thermoelement, resulting in incorrect readings.

The temperature at which a reaction begins is an indefinite one in nearly all cases. The time factor is very important. For example, a certain mixture of lime and silica will combine slowly at 1,200°, more rapidly at 1,300° and fairly rapidly at 1,400°, while the melting point of this particular mixture is 1,512° C. It depends altogether on how much time is given whether or not one will conclude that the reaction takes place at any one of the above temperatures.

It is commonly stated that the temperature of formation of a slag lies above its melting temperature, but this is only an accident of shop practice. If the materials are finely ground and intimately mixed, combination will take place below the temperature of fusion, and the observed phenomenon is due entirely to the coarseness of the materials, rendering combination difficult.

At high temperatures, on account of large radiation, large variations of temperatures exist within the furnace.

The last part of Mr. Shepherd's paper deals with possible errors in radiation pyrometry. One fundamental error which can be made if the user does not understand the theory of the instrument is possible with pyrometers based upon the theory of radiation from "black bodies." If the bodies do not radiate as "black bodies" in the thermodynamical sense the instrument does not give the exact temperature. Further in certain cases when dense vapors are given off it is folly to try to determine the temperature of the substance which is emitting the vapor. In carbon tube furnaces, for example, there is a liability of a carbon flame playing about the mouth or in the neck of the furnace, which may be several hundred degrees different in its temperature from that of the middle of the furnace.

The interest which is being taken at present in pyrometry was indicated by the lively discussion which followed. Mr. F. F. Schuetz, of New York, spoke at some length on the part of Mr. Shepherd's paper dealing with the thermoelectric type of pyrometer. Mr. Schuetz considers that the thermoelectric pyrometer is destined to be of the most important form for temperature measurements up to 3,000° F., or 1,600° C., being capable of both indicating and recording temperatures and adaptable to a great number and great variety of industrial applications. He emphasized that for industrial purposes a pyrometer should be used which eliminates the personal equation. With respect to the contamination of the elements composing the couple through contact with the material into which it is inserted, or through vapors given off from metals, etc., he thought that it is not necessary to use platinum and platinum-rhodium at temperatures below, say, 2,600° F., and that better results can be obtained with cheaper elements composed of such materials as nickel, steel, tungsten, copper, constantine, nickel steel, german silver, etc. Such couples, if properly protected and insulated, give good results. For this purpose each element should be first wound with asbestos thread and then coated with carborundum paint, using sodium

silicate as a binder. For protection against temperatures above 2,000° F. special tubes of nickel, plumbago or porcelain may be employed. For use in lead baths and the like the asbestos-carborundum-insulated couples may be further protected by an iron pipe welded together at the exposed end. These methods are used in the new Bristol low-resistance pyrometer (which was described in detail in our March issue, p. 115).

The Bristol pyrometer also avoids in an ingenious way the necessity of keeping the cold anode artificially at a constant temperature, since it contains an automatic compensating device (which was fully described in our March issue). Further, with the same instrument, there is no difficulty of the galvanometer needle sticking, since this is not likely to occur in a low-resistance system, owing to the greater motive power behind the needle. It is possible with this instrument also to readily estimate the temperature to 1° F. With respect to the point made by Mr. Shepherd, that the temperature at different parts of the furnace may vary, Mr. Schuetz recommends to place a number of couples at various parts of the furnace, to connect them to a common indicating instrument and to use a suitable switching device, by means of which the temperature of practically every point of the furnace may be quickly determined. Any lag, error or slowness in reaching thermal-equilibrium is to a great extent overcome by reducing the cross-section of the hot end of the couple, a practically instantaneous response to variations of temperature then being observed. Mr. Schuetz concludes that the thermoelectric pyrometer is now a thoroughly commercial and reliable instrument, able to withstand ordinary wear and tear and capable of being entrusted to workmen of ordinary intelligence.

In the further discussion, in which, among others, Messrs. Sperry, Burgess, Cowles and Bancroft participated, several speakers stated that they had used the Bristol pyrometer and had found it very useful and convenient, and that at the price at which the instrument is furnished quite a number of couples could be employed in practice. Prof. Burgess urged that the seller of thermoelectric couples should inform the purchaser concerning the composition of the couples, so that he may know with which metals and at which temperatures it is safe to employ them without fearing detrimental reactions. Mr. Howard briefly referred to the use of the Uehling pyrometer. Prof. Richards emphasized the importance of the time factor in investigating reactions, and agreed with the author of the paper that Seger cones must be handled very carefully to get good results.

On motion of Prof. Richards a resolution was then adopted expressing the thanks of the Society to all those who had made the meeting such a successful one, especially to Cornell University and the different departments visited, to the local committee and to the industries of Ithaca who had opened their shops to the visitors. This was the official conclusion of the ninth meeting of the American Electrochemical Society.

THURSDAY AFTERNOON.

A very interesting excursion was made Thursday afternoon to the works of the Remington Salt Co. The visitors studied with great interest the pumping machinery which lifts, from a depth of ½ mile, the brine, which is then evaporated in a large vacuum pan; this is followed by drying the crystallized salt by the centrifugal process and by final drying in a rotary drum. Two special and very enjoyable features of Thursday afternoon and evening were two lectures by Mr. E. G. Acheson and Dr. H. W. Wiley, which, however, were not directly connected with the meeting of the American Electrochemical Society.

DISCOVERY AND INVENTION.

Mr. E. G. ACHESON, the distinguished electrochemical inventor, of Niagara Falls, addressed the engineering students of Cornell University in the Sibley Dome on "Discovery and Invention." In the introduction he spoke of Faraday as the

representative of discovery without invention, of Bessemer as the representative of invention without discovery, and of Goodyear as both a discoverer and inventor. The main part of the address dealt with the author's own work on carborundum, artificial graphite and siloxicon. Mr. Acheson exhibited a great many of his products, and his lecture was full of interesting and suggestive remarks, and of reminiscences of his early work with Mr. Edison.

FOODS.

In the evening Dr. H. W. WILEY, of Washington, D. C., spoke before the Cornell Section of the American Chemical Society on some special problems of the food question. His lecture was illustrated by lantern slides, and the author discussed the methods of testing foods and their adulterations.

THE NEW PRESIDENT.

The new president of the American Electrochemical Society, Mr. CARL HERING was born 1860, in Philadelphia, Pa., and is one of the five surviving sons of the late Dr. Constantine Hering. He studied mechanical engineering at the University of Pennsylvania, graduating with high honors in 1880, with the degree of bachelor of science. Some years later he received the post-graduate degree of mechanical engineer. For a year after graduation he practiced as draughtsman and designer of machinery, and was then appointed instructor in mathematics and assistant in mechanical engineering at the University of Pennsylvania, and in 1882 assistant in physics, which position he took in order to begin studying electrical engineering. There being no college in this country at that time where electrical engineering was taught as a regular course, he went, in 1883, to Darmstadt, Germany, where he studied under Prof. Kittler, and was soon after made the latter's assistant.

Mr. Hering was assistant electrician at the International



CARL HERING.

Electrical Exhibition in Philadelphia in 1884, and participated in the first extended comparative life test of the electric incandescent lamps at that time on the market. In 1885 he was chief electrical engineer for a large electrical company in Germany, and later for a company in Philadelphia. In 1886 to 1887 he taught electrical engineering at the

University of Pennsylvania. In 1892 he was technical editor of *Electrical World*. Since 1886 he has been practicing as consulting electrical engineer in Philadelphia, being engaged chiefly with tests, reports, patent litigations and acting as consulting engineer for companies.

The high esteem in which Mr. Hering is held for his knowledge, experience and independence has often found recognition. He was a member of the Jury of Awards at the following expositions: Vienna, 1883; Philadelphia, 1884; Paris, 1889; St. Louis, 1890; Frankfurt, 1891; Philadelphia, 1899; Paris, 1900 (a member of the highest or superior jury); Buffalo, 1901 (chairman of Jury of Awards for the electrical exhibits and member of the Superior Jury); St. Louis, 1904 (chairman of group jury on electrochemistry and a member of the higher department jury for the Department of Electricity). In recognition of his services at the Paris Exposition in 1900 the French Government conferred on him the

decoration of the Cross of the Legion of Honor, popularly known as the "red ribbon."

Mr. Carl Hering was an active member of the following international electrical congresses: In Frankfurt, 1891, he was a delegate and vice-president. In 1893 he was an active member of the committee to prepare the preliminary programme for the Chicago International Electrical Congress. In 1900 he was a delegate and vice-president at the Paris Congress. In 1903 he was a member of the advisory committee of the International Electrical Congress of St. Louis of 1904, at which Congress he was the secretary of the Section on Electrochemistry.

Mr. Carl Hering is a member of numerous engineering and scientific societies. He is an honorary member of the New York Electrical Society, and was elected president of the American Institute of Electrical Engineers in 1900, president of the Engineers' Club of Philadelphia in 1904, and president of the American Electrochemical Society in 1906.

In spite of his extensive practice as consulting engineer, Mr. Hering has found time to present numerous valuable papers to the societies of which he is a member, and has been a frequent contributor to the technical press. In 1904 he published a book on "Ready Reference Tables," containing conversion factors of every unit or measure in use, enabling anyone to be readily reduced to any of the others and based on the accurate legal standard values of the United States. It is probably the first book of its kind published and based on the accurate legal standards. (An appreciative comment on this excellent book may be found on page 329 of our Vol. II.)

Mr. Hering's work in electrochemistry began with extended researches on accumulators, for which he obtained numerous patents. He also made extended researches concerning the commercial regeneration of spent battery solutions, including the recovery of the zinc, the reoxidization of the depolarizer and the separation of the acid and the depolarizer. Some years ago he made a complete recalculation of all electrochemical equivalents, based on the most recent, standard, fundamental values, and published the same in our Vol. I., p. 169.

In 1900 Mr. Hering made some very extended tests on a crude furnace for the recovery of arsenic from its ore, from which he deduced the figures for a properly constructed electric furnace, which calculation involved considerable labor and research to find out how much the losses could be reduced, as the losses in the crude furnace were very great. He has also designed other furnaces and has acted as consulting engineer in other industrial electrochemical work. He has devised and patented a method of getting zinc and similar metals out of their solutions when the products formed interfere with the process, as is the case when zinc is extracted from its sulphate. In this way he has obtained about 94 per cent of the zinc from the sulphate, with an ampere-hour efficiency of over 90 per cent. He was married in 1892, and has one young daughter.

In the following we give a complete list of the members and guests who registered at the Cornell meeting:

E. G. Acheson, Niagara Falls, N. Y.; Charles E. Acker, Niagara Falls, N. Y.; William C. Arsem, Schenectady, N. Y.; Edgar A. Ashcroft, London, England; Wilder D. Bancroft, Ithaca, N. Y.; John A. Black, Lima, Ohio; E. Blough, Pittsburg, Pa.; M. J. Brown, Tecumseh, Neb.; A. W. Browne, Ithaca, N. Y.; William Hand Browne, Jr., New York City; Hubert Buckley, Rochester, N. Y.; Charles F. Burgess, Madison, Wis.; H. G. Burnham, Ithaca, N. Y.; A. D. Camp, Ithaca, N. Y.; C. F. Carrier, Jr., Elmira, N. Y.; H. R. Carveth, Niagara Falls, N. Y.; G. W. Cavanaugh, Ithaca, N. Y.; H. B. Coho, New York City; C. L. Collens, 2d, Niagara Falls, N. Y.; B. E. Curry, Bloomington, Ind.; M. Dennis, Ithaca, N. Y.; J. Forssell, Cleveland, Ohio; J. J. Frank, New York City; F. E. Gallagher, Ithaca, N. Y.; W. C. Geer, Ithaca, N. Y.; J. K. Gillis, Ithaca, N. Y.; C. P. Goepel, New York City; J. H. Goodwin, Pen Yan, N. Y.; F. X. Govers, Owego, N. Y.; Frank Hawkins, Hamden Junction, Ohio; L. F. Hawley, Ithaca, N. Y.; Carl Hering, Philadelphia, Pa.; Geo. A. Hulett, Princeton, N. J.; Henry Howard, Boston, Mass.; M. A. Hunter, Schenectady, N. Y.; F. H. Jennings, Ithaca, N. Y.; J. P. Magnusson, Ithaca, N. Y.; F. A. Mantel, Ithaca, N. Y.; F. C. Mathers, Ithaca, N. Y.; H. T. Matthew, New York City; W. E. McCourt, New York City; W. H.

McLanchlan, Bradford, Pa.; M. F. Mehling, Cleveland, Ohio; W. Lash Miller, Toronto, Ont.; Howard D. Minchin, Rochester, N. Y.; H. H. Norris, Ithaca, N. Y.; C. S. Palmer, New York City; H. E. Patten, Washington, D. C.; J. E. Randall, Cleveland, Ohio; G. A. Rankin, Ithaca, N. Y.; J. W. Richards and Mrs. Richards, Bethlehem, Pa.; George C. Robertson, Ithaca, N. Y.; Hugh Rodman, Pittsburg, Pa.; E. F. Roerber, New York City; S. S. Sadler, Philadelphia, Pa.; Carl C. Schluederberg, Ithaca, N. Y.; F. F. Schuetz, New York City; R. C. Snowdon, Ithaca, N. Y.; Elmer A. Sperry, New York City; Henry P. Talbot, Boston, Mass.; J. E. Teeple, New York City; Edward C. Tice, Ithaca, N. Y.; Maximilian Toch, New York City; Clinton Paul Townsend, Washington, D. C.; J. W. Turrentine, Ithaca, N. Y.; W. H. Walker, Boston; G. Robert White, Ithaca, N. Y.; H. W. Wiley, Washington, D. C.; J. Lanson Wills, New York City; C. I. Zimmerman, Niagara Falls, N. Y.

Metallurgical Calculations.

By J. W. RICHARDS, PH. D.

Professor of Metallurgy in Lehigh University.

UTILIZATION OF FUEL IN THE BLAST FURNACE.

The blast furnace, in its simplest terms, may be regarded as a huge gas producer, producing in the region of the tuyeres pure producer gas from fixed carbon and heated air; the gas thus produced is partly oxidized in its ascent through the furnace by the oxygen abstracted from the charge (which latter item is almost a constant quantity per unit of pig iron made), and has added to it carbon dioxide from the carbonates of the charge. But, after all, the unoxidized and combustible ingredients of the gas escaping represent a large part, in fact, often the largest part, of the total calorific power of the fuel.

Problem 54.

A blast furnace uses 2,240 pounds of coke, containing 90 per cent fixed carbon and 350 pounds of limestone, containing 10 per cent of carbon (as carbonic acid, CO_2) to produce a ton of pig iron containing 4 per cent of carbon. The gases contain 24 per cent of carbonous oxide, CO , 12 per cent of carbonic oxide, CO_2 , 2 per cent of hydrogen, 2 per cent of methane, and 60 per cent of nitrogen.

Required: (1) The volume of gas, as analyzed, produced per ton of pig iron made:

(2) The calorific power of the gas.

(3) The proportion of the calorific power of the coke which has been generated in the furnace.

Solution: (1) The carbon going into the gases will be that in the coke, less that in the pig iron, plus that in the carbonates of the charge.

Carbon in coke	$= 2,240 \times 0.90 = 2,016$ pounds
Carbon in carbonates	$= 350 \times 0.10 = 35$ "
Carbon charged	$= 2,051$ "
Carbon in pig iron	$= 2,240 \times 0.04 = 89.6$ "

Carbon going into the gases	$= 1,961.4$ "
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Carbon in 1 cubic foot of gas:

In CO 0.24×0.54

In CO_2 0.12×0.54

In CH_4 0.02×0.54

Total $0.38 \times 0.54 = 0.2052$ ounces average
 $= 0.012825$ pounds

Gas produced per ton of pig iron $= \frac{1,961.4}{0.012825} = 152,935$ cu. ft. (1)

(2) Calorific power of 1 cubic foot of gas:

CO $0.24 \times 3,062 = 734.9$ oz. cal.

H_2 $0.02 \times 2,613 = 52.3$ "

CH_4 $0.02 \times 8,598 = 172.0$ "

Sum $= 959.2$ "

$= 59.95$ pound cal.

per 152,935 cubic feet $= 9,168,450$ pound cal. (2)

(3) The calorific power of the coke, considering it to contain simply 90 per cent of fixed carbon, would be

$$8,100 \times 0.90 = 7,290 \text{ pound cal. per pound.}$$

The presence of CH^4 in the gases points, however, to there being probably some available hydrogen in it, which would increase its calorific power somewhat. A closer approximation to the calorific power of the coke could, therefore, be obtained by assuming at least as much available hydrogen in it as would correspond to the hydrogen in the CH^4 in the gas.

CH^4 in 152,935 cu. ft. of gas	=	3,059 cu. ft.
Weight of this = $3,059 \times (0.09 \times 8)$	=	2,202 oz. av.
	=	137.7 lbs.
Hydrogen = $137.7 \times (4 \div 16)$	=	34.4 lbs.
Available hydrogen in coke = $34.4 \div 2.240$	=	1.54 per cent
Calorific power $0.0154 \times 29,030$	=	447 lb. cal. per lb.
Total calorific power of the coke	=	7,737 " "
Calorific power of coke used per ton $7,737 \times 2.240$	=	17,330,880 lb. cal.
Calorific power of the gases	=	9,168,450 "
Calorific power generated	=	8,162,430 "
	=	47.1 per cent

This figure, however, practically over-charges the furnace a little bit, because the pig iron with its 4 per cent of carbon really takes out of the furnace some unburnt fuel, whose heat of combustion may be utilized outside the furnace—as in the Bessemer converter. The furnace does not generate heat from this, representing:

$$\begin{aligned} 2,240 \times 0.04 \times 8,100 &= 725,760 \text{ lb. cal.} \\ \text{leaving as actually generated in the furnace} \\ 8,162,430 - 725,760 &= 7,436,670 \text{ lb. cal.} \\ &= 42.9 \text{ per cent} \quad (3) \end{aligned}$$

Such an average blast furnace cannot, therefore, be accused of generating within it over some 43 per cent of the calorific power of the fuel put into it, while the heat rejected as potential energy of combustion of the waste gases amounts to more than half the calorific power of the fuel. Fifty years or more ago, when these waste gases were allowed to burn truly to waste, the blast furnace was indeed a devourer of fuel, but matters have been improved by the utilization of the waste gases to heat the blast, and thus one of the largest "leaks" of heat from the furnace has been patched up to some extent, although yet far from satisfactorily.

Problem 55.

Assume that in problem 54, one-third of the gases produced are burnt in hot-blast stoves, preheating the air blown in at the tuyeres, and that the blast is thus preheated to 450°C .

Required: (1) The amount of blast blown in per ton of pig iron made.

(2) The heat in the blast.

(3) The efficiency of the hot-blast stoves.

(4) The increased efficiency of the blast furnace plant as a whole in generating the calorific power of the fuel, when thus provided with this hot-blast apparatus.

Solution:

(1) Volume of (dry) gases per ton	=	152,935 cu. ft.
Nitrogen present in these (60%)	=	91,761 "
	=	91,761
Air containing this = $\frac{\quad}{0.792}$	=	115,860 "
	=	0.792 \quad (1)

This is the volume of the blast per ton of pig iron produced, assuming no nitrogen to come from the coke used, and the blast to be dry. If the blast were moist, and its hygrometric condition known, the volume of moist blast could be calculated.

(2) Assuming the blast dry, it is heated to 450°C , requiring

$$115,860 \times [0.303 + 0.000027 (450)] \times 450 = 16,430,975 \text{ oz. cal.} \\ = 1,026,936 \text{ lb. cal.}$$

(3) The hot-blast stoves receive one-third of all the gas produced, having, therefore, a calorific power of

$$\frac{9,168,450}{3} = 3,056,150 \text{ lb. cal.}$$

$$\text{Efficiency of the stoves} = \frac{1,026,936}{3,056,150} = 0.336 = 33.6 \text{ per cent} \quad (3)$$

(4) The blast furnace was primarily rejecting unused 57.1 per cent of the calorific power of the fuel, 4.2 per cent, however, as a necessary loss, to supply the carbon in the pig iron, but 52.9 per cent as combustible power of unburnt waste gases. If one-third of these gases are completely burnt in hot-blast stoves, then the combined plant—furnace plus stoves—is utilizing 17.6 per cent more of the calorific power of the fuel than before, or $42.9 + 17.6 = 60.5$ per cent, and, therefore, rejecting undeveloped 39.5 per cent of the calorific power. (4)

[The net effect of the use of the hot-blast stove, upon the heat generation in the furnace, is practically to put back into the furnace, as sensible heat, $1.3 \times 33.6 = 11.2$ per cent of the calorific power of the waste gases, equal, therefore, to $0.112 \times 52.9 = 5.9$ per cent of the total calorific power of the fuel. This renders available, for the working of the furnace, $42.9 + 5.9 = 48.8$ per cent of the calorific power of the fuel, an in-

$$\begin{aligned} \text{crease of available heat for reducing and smelting of} &= \frac{5.9}{42.9} \\ &= 13.7 \text{ per cent of the former available quantity.}] \end{aligned}$$

The practical conclusion is that a blast furnace generates in itself not much over 40 per cent of the calorific power of the fuel used, and rejects nearly 60 per cent; by using part of the waste gases to heat the blast, however, some of this rejected heat, to an amount representing net 5 to 10 per cent of the calorific power of the fuel used, is returned to and injected bodily into the furnace, thus rendering available for the purposes of running the furnace some 50 per cent of the calorific power of the fuel as a maximum. The efficiency with which the furnace applies this 50 per cent usefully to the objects of reducing and smelting, is another question for investigation.

Problem 56.

Assume that at the furnace of Problems 54 and 55 the two-thirds of the waste gases are burnt under boilers, raising steam which runs the blowing engines, hoists and pumps, and providing 10 effective horse-power for each ton of pig iron made per day in the furnace.

Required: (1) The efficiency of development of the calorific power of the fuel in the plant (furnace, stoves, boilers, engines) regarded as a whole.

(2) The thermo-mechanical efficiency of the boiler and engine plant.

(3) The power which could be generated if gas engines, at 25 per cent thermo-mechanical efficiency, were used in their stead.

Solution: (1) Since the stoves completely burn one-third of the waste gases, and the boilers the other two-thirds, all the combustible power of the waste gases is developed in the combined plant, and the only part of the calorific power of the fuel which is unused is the 4.9 per cent represented by the carbon necessarily entering into the composition of the pig iron. The plant as a whole, therefore, develops or generates 95.1 per cent of the calorific power of the fuel used.

(2) For each ton of pig iron, the heat developed under the boilers will be two-thirds of the calorific power of the gases, or

$$9,168,450 \times 2.3 = 6,112,300 \text{ lb. cal.}$$

There is generated thereby 10 effective horse-power days, equal to

$$10 \times 33,000 \times 60 \times 24 = 475,200,000 \text{ ft. lbs.}$$

$$\text{But 1 lb. cal.} = 425 \times 3.2808 = 1394.3 \text{ "}$$

Therefore, thermal equivalent of

$$\frac{475,200,000}{1394.3} = 340,800 \text{ lb. cal.}$$

Thermo-mechanical efficiency of boiler and engine plant:

$$\frac{340,800}{6,112,300} = 0.0557 = 5.57 \text{ per cent} \quad (2)$$

(3) Gas engines, at 25 per cent thermomechanical efficiency, would give power representing per ton of pig iron produced:

$$6,112,300 \times 0.25 = 1,528,075 \text{ lb. cal.}$$

$$\text{Equal to } \frac{1,528,075 \times 1394.3}{2,130,645,900} = 2,130,645,900 \text{ ft. lbs.}$$

$$\text{or } \frac{33,000 \times 60 \times 24}{25} = 44.9 \text{ horse-power days.} \quad (3)$$

A quicker solution is:

$$10 \times \frac{25}{5.57} = 44.9 \text{ " " " } \quad (3)$$

Leaving net *surplus* power per ton of pig iron produced per day = 34.9 horse-power.

The preceding problems have elucidated the question of the small proportion of the calorific power of the fuel which is generated in a blast furnace, showing it to be, in usual practice, only 40 to, at most, 50 per cent of the calorific power. The discussion has not explained "why," but a further consideration will throw light on this question also.

The proportion of the calorific power of a fuel which is generated in a blast furnace is solely a question of how much of it is burned to carbonic oxide, CO^2 , and how much to carbonous oxide, CO ? If all the carbon were burned to CO^2 , practically all the calorific power of the fuel would be generated; if all

$$\text{were burned to CO, only } \frac{2,430}{8,100} = 0.30 = 30 \text{ per cent of the}$$

heating power of the carbon would be generated. If a blast furnace was filled with nothing but coke, and air blown in as usual at the tuyeres, carbon would be burned in the furnace only to CO , and but 30 per cent of its calorific power be generated and available for the needs of the furnace. The entire gain over this percentage is due to the oxidation of CO to CO^2 by the oxygen abstracted from the solid charges, that is, by the act of reduction. In Problem 54 we calculated that under ordinary conditions, between 40 and 50 per cent of the calorific power of the fuel is generated in the furnace; the excess of this above 30 per cent is due to the oxidation of CO to CO^2 during the reduction of the metallic oxides in the charge. From this standpoint it is advisable to strive to perform the greatest possible proportion of the reduction in the furnace by CO gas, because in this case the total generation of heat in the furnace per unit of fuel charged will tend towards a maximum. Since no carbon can be burned to CO^2 at the tuyeres, it follows that, from the standpoint of the generation of the maximum quantity of heat in the furnace from a given weight of fuel, Grüner was right in formulating his dictum of the ideal working of a blast furnace, viz.:

GRÜNER'S "IDEAL WORKING."

All the carbon burnt in the furnace should be first oxidized at the tuyeres to CO , and all reduction of oxides above the tuyeres should be caused by CO , which thus becomes CO^2 . This dictum is not in Grüner's own words, but expresses their sense, and from the point of view of the present discussion, it is the correct principle upon which to obtain the maximum generation of heat in the furnace from a given weight of fuel. It practically directs us to generate at the tuyeres 30 per cent of the calorific power of the carbon oxidized in the furnace,

and the rest that can be obtained from the carbon is to be generated during the reduction of the charge.

If we apply this principle to the furnace and data of Problem 54, we should first observe that the carbon oxidized in the furnace is::

$$\text{Carbon in coke charged..... 2076 pounds}$$

$$\text{Carbon in pig iron produced..... 89.6 "}$$

$$\text{Carbon oxidized in furnace..... 1926.6 "}$$

Requiring, if all oxidized to CO at the tuyeres

$$1926.6 \times \frac{4}{3} \text{ lbs. oxygen} = 2569 \text{ pounds}$$

But, Problem 52 showed us that there was actually blown into this furnace 115,860 cubic feet of blast, containing, therefore,

$$115,860 \times 0.208 \times (1.44 \div 16) = 2,169 \text{ lbs. oxygen, capable of oxidizing to CO at the tuyeres}$$

$$2,169 \times 0.75 = 1,627 \text{ lbs. carbon.}$$

Proportion of carbon gasified burnt at the tuyeres,

$$\frac{1,627}{1926.6} = 0.844 = 84.4 \text{ per cent.}$$

It is, therefore, true of the furnace under discussion, that if Grüner's ideal working be called standard, this furnace attains to 84.4 per cent of that ideal; and it is also true that this furnace generates from the carbon burnt at the tuyeres 84.4 per cent of the amount of heat which could have been generated if Grüner's ideal working had been attained.

It is always possible to find out for any given blast furnace, by similar calculations, how much carbon is burned at the tuyeres, and how much is burned above the tuyeres, and thus to determine how closely the furnace running approximates to Grüner's ideal working. This proportion or percentage will not necessarily express how efficiently the furnace is running, as regards fuel used per unit of iron made, but it will tell what proportion of the calorific power of the fuel used is being generated at the tuyeres, and in possibly nine cases out of ten this proportion indicates the general efficiency of the furnace as regards fuel consumption.

It will be next profitable to inquire when and under what conditions Grüner's ideal working does not correspond to maximum fuel economy, and why it usually does. The answer is not difficult to understand: if all the carbon gasified in the furnace is burned to CO at the tuyeres, 30 per cent of the total calorific power of the carbon burned is there developed, which is more than half of all the heat generated from carbon in the furnace. To this must also be added the sensible heat in hot blast, which may amount (as in Problem 52) to some 5.9 per cent of the calorific power of the carbon, making, therefore, a total of 35 per cent of the calorific energy of the fuel generated at the tuyeres out of a total of about 50 per cent developed in the furnace. If, however, the blast be heated to a very high temperature, or particularly if it be dried, or if the ore and fuel are extra pure, so that a smaller quantity of heat is needed to melt down slag at the tuyeres, then there may not be needed at the tuyeres the generation by combustion of so much heat as Grüner's ideal working would require and cause to be produced, and to burn at the tuyeres all the carbon oxidized in the furnace would be wasteful of fuel. In this case, although less heat would be generated per unit of fuel, by burning some of it above the tuyeres, yet economy in fuel consumption as a whole would be attained, because of the *better distribution* of the heat which was generated from a smaller total quantity of fuel.

Illustration: In Problem 55 we assumed that the furnace ran with blast heated to 450°C. and that this hot blast, burning at the tuyeres 84.4 per cent of all the carbon gasified in the furnace, smelted down pig iron and slag satisfactorily and kept

the tuyere region at proper temperature. If the temperature of this blast were raised to 900° C., how much greater proportion of heat would be available in the tuyere region?

We have already calculated that the 115,860 cubic feet of blast used per ton of iron made, brought in at 450° C., 1,026,936 pound calories of heat, equal to 5.9 per cent of the calorific power of the fuel put into the furnace. If the temperature were 900° C., the heat brought in would be

$$115,860 \times [0.303 + 0.000027(900)] \times 900 = 37,920,978 \text{ oz. cal.} \\ = 2,370,061 \text{ lb. cal.}$$

which equals

$$\frac{2,370,061}{17,330,880} = 0.137 = 13.7 \text{ per cent}$$

of the calorific power of the fuel, a gain of 7.8 per cent added to the heat available in the tuyere region. This causes a very great increase in the smelting-down power of the furnace, enabling the same work per ton of ore smelted to be done with much less consumption of fuel in the tuyere region. An idea of this increased smelting power may be obtained from the following comparison of heat available for smelting purposes in the tuyere region in the two cases just discussed:

CASE 1.

Heat developed by oxidation of carbon per ton of iron made, 1,627 lbs. \times 2,430 = 3,953,610 lb. cal.
Sensible heat in blast at 450° C. = 1,026,936 "

Total heat available = 4,980,546 "

CASE 2.

Heat developed by same quantity of air burning same carbon = 3,953,610 "
Sensible heat in blast at 900° C. = 2,370,061 "

Total heat available = 6,323,671 "

It is, therefore, seen that the heat generated and available at the tuyeres is increased 1,343,125 calories, amounting to 27 per cent of the amount disposable in Case 1. It follows, therefore, that the smelting down power has been increased 27 per cent, and that, if the 4,980,546 calories were sufficient for satisfactorily smelting down the iron and slag in the first instance, that the extra heat of Case 2 can all be utilized for smelting down 27 per cent extra burden. We can, therefore, charge 27 per cent more burden per unit weight of coke in Case 2, because we have the requisite smelting down power at the region of the tuyeres, which amounts to saying that we can charge 22 per cent less coke for a given weight of pig iron made.

In actual practice, as the amount of burden is increased and the temperature of the blast increased, the change causes more and more of the carbon to be oxidized above the tuyeres, and a smaller proportion to be oxidized at the tuyeres, thus obtaining less service in the furnace from oxidation of carbon as a whole, but compensating for this by the extra heat in the hot blast. Or, looking at it in another way, we may say that the same heat could be made available in the region of the tuyeres, when using hot blast, by the combustion there of a smaller quantity of carbon; therefore, we can burn more of it above the tuyeres and yet work more economically on the whole, than we were working in the first instance, with the colder blast.

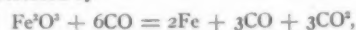
MINIMUM CARBON NECESSARY IN THE FURNACE.

Many writers have assumed that in the reduction of iron oxide, such as Fe_2O_3 , the reaction of its reduction by carbonous oxide, CO, is expressed as follows:



If this were true, there would need to be burnt to CO at the tuyeres only 3C, or 36 parts of carbon, to ensure the reduction of Fe_2O_3 , representing 112 parts of iron. The reaction does

not, however, progress as shown, because CO_2 acts oxidizingly on Fe to such a degree that when 1CO² is present in the gas for 1CO left unused, the reduction practically stops, even though the gases are moving slowly through the warm ore. The real reaction of reduction by CO gas is therefore more nearly represented by



which shows that 112 parts of iron would require at least 72 parts of carbon to be oxidized at the tuyeres to CO, in order to produce the gas necessary for its reduction. The presence of some CO_2 in the furnace coming directly from carbonates in the charge would neutralize still more of the reducing power of the CO gas, and cause still more of it to be theoretically required for reduction. The minimum amount of carbon necessary to be charged in the furnace will be that necessary to furnish fixed carbon enough for this reducing gas and for the carbon in the pig iron. This would be, per 100 parts of pig iron, containing, say 93 iron and 3 carbon, and using coke containing 90 per cent of fixed carbon:

$$\begin{array}{rcl} \text{Carbon burnt at tuyeres} & = 72 \times 93 \div 112 & = 59.8 \\ \text{Carbon in pig iron} & & = 3.0 \end{array}$$

$$\text{Total fixed carbon necessary} = 62.8$$

$$\text{Total coke to supply this} = 62.8 \div 0.9 = 69.8$$

It results from these calculations that if "Grüner's ideal working" of a blast furnace were carried out to the practical extent of reducing all the charge by carbonous oxide, CO, and oxidizing no carbon at all directly above the tuyeres, that about 63 parts of fixed carbon would be required per 100 of pig iron made, requiring from 70 to 80 parts of fuel, according to its richness in fixed carbon (90 to 80 per cent). In practice, as is well known, more than this is commonly used, because of the larger proportion of unused CO in the gases than above assumed; and less than this has been regularly used, showing that economy of fuel can be attained without adhering to "Grüner's ideal working," in fact, by transgressing it as far as one dares.

The principle involved can be best grasped by a calculation of the amount of carbon which would be required by the furnace, supposing all the heat necessary for melting down the charge were supplied by electrical means, thus dispensing, for the purposes of this supposition, with the necessity of blast and the consequent necessity of oxidizing any carbon by any other agent than the oxygen given up by the ore. In this case the gases resulting would be, let us assume, of the same composition as before, that is, containing equal volumes of CO and CO_2 , and since this oxygen is abstracted altogether from the ore, the reaction is



This would represent the utilization of carbon in an electrically-heated furnace, and would require per 100 of pig iron made, assuming it 3 per cent carbon and 93 iron:

$$\begin{array}{rcl} \text{Carbon for reduction} & 24 \times 93 \div 112 & = 19.9 \\ \text{Carbon in pig iron} & & = 3.0 \end{array}$$

$$\text{Total fixed carbon necessary} = 22.9$$

Or only a little over one-third as much as the minimum required when the smelting down is done by blast.

Aside from electrical furnace practice, however, this discussion proves that whatever fixed carbon burns or oxidizes above the region of the tuyeres, in a blast furnace, absorbs oxygen from the charges with three times the efficiency of carbon first burnt at the tuyeres. Every pound of oxygen abstracted from the charges by solid carbon requires the use or intervention of only one-third as much carbon as that which is abstracted by CO gas; or, each pound of carbon abstracting oxygen directly from the charge takes from it three times as much oxygen as a pound of carbon first burnt to CO at the tuyeres possibly can.

The ordinary furnace produces at the tuyeres, in order to get

heat enough to melt down the charges, more CO gas than is needed to abstract all the oxygen from the charges; under these conditions it is uneconomical to oxidize any carbon at all above the tuyeres. The exceptional furnace, because of pure ores, small amount of slag, pure fuel, high temperature of blast, or dry blast, gets heat enough at the tuyeres to melt down the charges without producing enough CO gas to reduce all the charges; under these conditions more or less reduction is effected by solid carbon, and with the greatest economy in quantity of carbon required in the furnace. These are the conditions under which, having passed the turning point, the greater economy of fuel is attained the farther away one can get from "Grüner's ideal working."

Notes on Electrochemistry and Metallurgy in Great Britain

(From Our London Correspondent.)

ELECTROLYTIC RECTIFIERS.

A most interesting paper on "The Construction and Use of Oscillation Valves for Rectifying High-Frequency Currents," was recently read before the Physical Society by Prof. Fleming, in which the author recalled the fact that as far back as 1890, when investigating the Edison effect in glow-lamps, he had shown that the space between the incandescent carbon filament and an insulated metal plate placed in the vacuum bulb possessed a unilateral conductivity. Electrolytic rectifiers, such as the aluminium-carbon cell, were not available for high frequency currents, because a time element entered into the chemical actions involved. In 1904, however, the author discovered that if the carbon filament in an electric glow-lamp was surrounded with a metal cylinder connected to an insulated terminal by a wire sealed through the bulb, and if the filament was made incandescent by an insulated battery, then between the insulated terminal and the negative pole of the battery a unilateral conductivity existed which was operative with currents of any frequency, and the valve so made might be employed to render electrical oscillations measurable by an ordinary sensitive galvanometer. The author exhibited oscillation valves made on this plan, and also showed their uses. The advantage of using multiple spark-gaps in oscillation circuits was proved by the use of the valve. The author exhibited a multiple spark-gap discharger made with carbon rods, and claimed for it a much greater constancy of action than a discharger made with metal balls. Dr. Fleming also showed an experiment showing the copious emission of negative ions from the glow of a Nernst lamp at atmospheric pressure. The author referred to the employment of carbon-filament oscillation valves, such as he had described as wave detectors or cymoscopes in connection with wireless telegraphy. The amount of rectification produced by the valve could be measured, and might amount to 89 to 90 per cent.

MEETING OF THE FARADAY SOCIETY.

THE ELECTRIC FURNACE FOR IRON AND STEEL.

The chairman, Prof. Huntingdon, opened the proceedings at the April meeting by remarking that the Society was endeavoring to keep pace with the electric furnace developments. People were, however, working hard at the practical side, and had no time to read papers on the subject. Mr. Harbord had kindly consented to read the three papers relating to this subject before them that evening. (They were abstracted on page 167 of our May issue.)

Mr. Harbord then read Mr. Keller's paper, practically verbatim.

Mr. Morrison said this paper seemed to him too academical. Nothing was said about the furnace itself. There were many questions he should like to ask, amongst which was, whether difficulties due to the tap-holes "freezing up" had been got

over. Also what variations in firing should be effected to vary the quantity of silicon in 1,000 kilograms of metal. From the last paragraph it appeared that some doubt might still remain in Mr. Keller's mind as to the success of the present form of furnace.

The chairman remarked that makers would naturally be reticent about the details of their furnaces while in the experimental stage.

Mr. Harbord said that when he was present at the working of this furnace it "froze up." The current, however, passes whether the metal flows or not. He considered that Mr. Keller had exaggerated the possibility of making pig iron in electrical furnaces. Where anything like a large output was required this was impracticable. With regard to remelting of metal for castings, the metal would not, in the ordinary way, be taken direct from the blast furnace. The ordinary procedure is to obtain pigs of different percentage of silicon and mix them in the cupola.

Prof. Huntingdon said that in 1882 he had carried out experiments with the Siemens furnace, and that in that year a paper was read before the British Association, which seemed to be an effectual way of burying it. Experiments were made to find the maximum amount of carbon the pig would take up. Iron containing from $\frac{1}{4}$ to 9 per cent of silica was made, and its properties noted. That containing 2 per cent machined beautifully, producing an even surface. He also experimented on the elimination of sulphur, and thought that in these particulars he had anticipated Keller's experiments. In the course of these experiments they volatilized copper, and obtained also a mass of tungsten in crystals. This was the only solid tungsten which had been produced so far as he knew.

The paper on the Stassano furnace was next read.

Mr. Harbord said that the idea of rotating the Stassano furnace was to thoroughly mix the iron oxide with the metal. The inventor believes, and the speaker thought he was correct, that he can make steel direct from the ore in this furnace. The hearth was about 2 feet up from the base of the furnace.

Mr. Morrison asked if any figures relating to efficiency were available. Mr. Harbord could not at the time give figures, but believed the furnace to be not quite so efficient as Keller's or Héroult's. The electrodes did not touch the bath, and this he thought had disadvantages. Prof. Huntingdon surmised that the electrodes consumed more rapidly when touching the bath.

Mr. Harbord, in answer to Mr. Spiers, said he believed the rotation was at the rate of one or two revolutions per minute. He thought the rotation the weak point of the furnace.

In answer to Dr. Borns, he said the connections were made through an arrangement something like a trolley pole.

Mr. Harbord then read extracts from Mr. Gin's paper. He said the furnace was not commercially working anywhere when he was on the Continent.

Mr. Morrison had not heard of its being set up for that purpose, and thought it was in the experimental stage.

Mr. Weiss introduced the subject of power, and thought where water-power was not available gas power would be the cheapest. This was supported in the report of the Canadian Commission. He thought the electric furnace might be useful for smelting copper ore.

Mr. Harbord said good steel can be made in the electrical furnace. Prof. Huntingdon said that it might be used for high-class steel, but so far as could be seen at present, it would not come in much for commercial purposes.

Mr. H. S. Coleman's paper on "Cleaning Articles by the Electric Current" was read by the Secretary. The work to be cleaned (usually preparatory to electroplating) is suspended in a hot solution of equal quantities of brown Montreal potash and sodium hydrate in a wrought-iron tank. The tank is used as anode for 5 or 10 minutes, the voltage being about 2.5. The current is then reversed for a short time. The operation is

repeated. The grease becomes saponified and goes into solution. The lighter dirt is skimmed off from the surface of the bath, while the remainder falls to the bottom.

Dr. Borns thought the surface of the tank getting covered with oxide would interfere with the conductivity. Mr. F. S. Spiers said all the better if it did. It would prevent the tank getting eaten away.

METALLURGICAL PAPERS AT THE INSTITUTION OF MINING AND METALLURGY.

ASSAY OF AURIFEROUS TIN-STONE.

Chief among the metallurgical papers read at the meeting held on April 19, was that by Mr. C. O. Bannister "On the Assay of Auriferous Tin-Stone." Finding various discrepancies in the assay results of different chemists, the author compared the results obtained by the five different methods of:

1. Scorification assay.
2. Crucible assay.
3. Wet method.
4. Concentration of the gold in part of the tin.
5. Collection of the gold in the whole of the tin.

Omitting the laboratory details of the steps taken in each process the following are the author's conclusions:

The scorification method invariably gives low results for these ores, and this is due to the unsatisfactory nature of the slag obtainable. In rich ores the results may be improved by taking smaller quantities of ore, such as 2.5 to 3 gram; but in this case, any error occurring in the assay is largely magnified in calculating the results, and thus it is not advisable to use this method.

The crucible assay gives excellent results, both for silver and gold present, and as 25 grams can easily be worked off it is the most suitable method for most ores.

The wet method gives good results for the gold, but silver is not determined; this method, however, is far more tedious than the crucible assay, and the results obtained compare about equally with those obtained by that method.

The method by concentration in part of the tin gives low results, partly owing to gold being left in the slag, and also owing to loss on the treatment of the tin buttons; moreover, the silver results are unreliable.

The method of collection in the tin from the cyanide assay is suitable for detecting the presence of gold, but gives slightly low results as a method of assay, and is unreliable for the estimation of the silver contents.

The other papers read at this meeting were: "The Bucket Dredging Industry," by E. S. and G. N. Marks; "The Production of High-Grade Bullion from Zinc-Box Precipitates," by C. N. Morris; "On the Use of the Impact Screen in Tin Dressing," by J. H. Collins; "The Mitchell's Creek Gold Mines, New South Wales," by W. F. Macdonald, and "Notes on a Prospecting Shaft in the Goldfield District, Goldfield, Nev.," by E. A. Collins. The first three of these I have laid aside for subsequent abstracting when the rush of metallurgical society meetings has quieted.

These are to follow closely on each other this summer: The "James Forrest" lecture at the Institution of Civil Engineers, by Mr. R. A. Hadfield, is to be delivered on May 2. A week later the Iron and Steel Institute holds its May meeting, to be followed in July by its joint London meeting with the Institution of Mining Engineers. Meanwhile other societies continue their regular meetings.

THE RESISTANCE OF IRON AND STEEL TO REVERSALS OF DIRECT STRESS.

The Institution of Civil Engineers, *facile princeps* among the world's engineering institutions, can hardly be accused of pandering to the press, technical or popular. In a paternal way it issues an official résumé of each paper read to its selected press list, but absolutely bars any reporting of its meetings. From the official abstract of a paper on the above subject, by

Dr. T. A. Stanton and Mr. L. Bairston, I have noted the following points for transcription. The need for further research upon this subject is urged for these cogent reasons:

"(1) Practically all the previous work, with the exception of Reynolds and Smith's experiments, has been done by subjecting the materials to transverse stresses, the intensity of which has, therefore, to be calculated by the ordinary theory of bending. (2) The resistance of the materials in common use by the engineers at the present day when subject to reversals of stress is imperfectly known, and there exists considerable difference of opinion as to the materials best suited for stresses of this kind. (3) Although it appears from Reynolds and Smith's experiments that the resistance of iron and steel is seriously diminished when the alterations are very rapid (i. e., 1,500 to 2,000 per minute), it is not known if this reduction in resistance is considerable at those speeds which are common in high-speed reciprocating motors (i. e., in the neighborhood of 800 reversals per minute), since the majority of experiments have been made at approximately 60 reversals per minute. (4) Although it is generally recognized that the effect of moderately rapid or sudden changes in section of materials subject to reversals of stress is to diminish their resistance, the amount of this reduction in strength for the various materials commonly used is not known. (5) The common assumption that, in cases in which the stress varies from tension to compression, but between unequal limits, the resistance depends solely on the range of stress and not on the actual values of these limits, has not been experimentally verified."

The effect of reversals of direct stress was, therefore, investigated on a number of bars of iron and steel, the alternating stress testing machine at the National Physical Laboratory being used. A microscopical investigation was carried out concurrently to observe the changes taking place in the crystalline structure of the materials, and "to determine if possible the manner in which ultimate failure occurs."

The materials subjected to the tests may be considered in three groups:

(1) Three samples of Swedish Bessemer steel and one sample of Swedish charcoal iron, presented by Mr. R. A. Hadfield for the purpose. The carbon content of the steels was approximately 0.17, 0.44 and 0.64 per cent.

(2) Four samples of steel presented by Messrs. Belliss and Morcom for the purpose. Of these, two were mild-steel bars, one was a bar of harder steel used for piston rods, and the fourth consisted of specimens which had been cut from a large steel forging.

(3) Two samples of wrought iron of British manufacture, bought for the purpose of the tests.

Although more uniformity in the results of the tests would no doubt have been obtained by subjecting all the specimens cut from any given material to an annealing process, it was felt that this would detract from the value of the tests, owing to the well-known effect of heat treatment on the resistance of steel. For this reason the tests were made on the bars as received; and in cases in which there were several bars of the same material, the specimens in any group of tests were not always cut from the same bar. This does not apply to the case of the specimens whose structure was examined microscopically, in which the actual resistance was of secondary importance.

The results of the experiments may be stated briefly as follows:

1. The superiority, in resistance to reversals of stress, of moderately high-carbon steels over low-carbon steels and wrought irons, which was discovered by Wohler to exist when the rate of reversals was 60 per minute, still holds when this rate is increased to 800 per minute, although, according to Reynolds' and Smith's experiments, this superiority no longer exists when the rate of reversals is in the neighborhood of 2,000 per minute. 2. As far as comparisons can be made be-

tween the results of the present experiments and those of Wohler and Sir Benjamin Baker, there is no marked reduction in resistance due to raising the rate of reversals to 800 per minute. 3. Experiments in which the ratio of tension to compression varied from 1.14 to 0.73 indicated that between these limits the value of the maximum range of stress was practically independent of the actual values of the limiting stresses in tension and compression. 4. The resistance of the materials in three typical cases of rapid reduction of area of the specimens has been determined. 5. The failure of iron specimens, due to the development of the slip-lines of Ewing and Rosenhain into cracks, has been determined for the case of direct stress; and the failure of moderately high-carbon steel, due to the development of cracks in the ferritic areas of the structure, has also been established.

MARKET QUOTATIONS DURING APRIL.

The continued activity in the textile industries has maintained the price of the alkali and coal-tar products.

As regards metals, the price of copper was very firm throughout, rising from £83.15 per ton to £86 per ton. Copper sulphate has further advanced to £26 per ton. Tin, which stood at £169 per ton on March 30, rose by April 30 to £183 per ton. As a result renewed interest is being taken in various Cornish mining properties, and the reworking of certain abandoned mines seems quite feasible.

There has been no particular change in regard to iron, Cleveland warrants closing at £29.6. Lead has been in fair demand, prices being practically stationary. Zinc sheets are £2 dearer, at £30.5 per ton.

ANALYSIS OF CURRENT ELECTROCHEMICAL PATENTS.

ELECTRIC FURNACES.

Manufacture of Calcium Carbide.—H. L. Hartenstein, 819,218, 819,219, 819,220, 819,221, 819,222, 819,223 and 819,224, May 1. Applications filed July 23 and 26, 1902.

The Hartenstein process of making calcium carbide, or as he calls it, carbolite, is commercially operated in Constantine, Mich. This is the only case of competition with the Union Carbide Co., which, owing to the Willson patents, enjoys

otherwise a complete monopoly in the manufacture of calcium carbide in this country.

The first five patents of Hartenstein, mentioned above, refer to the process of manufacture, the last two to the construction of his electric furnace.

The whole scheme is indicated diagrammatically in Fig. 1. *A* is a hopper for limestone, crushed to about 20-mesh, *B* a hopper for coke, pulverized to about 50-mesh. These materials are passed to the automatic dumping scales *E* and then introduced into the "preheating furnace" *C*. This is heated by means of the burner *F*, which delivers into the furnace coal dust

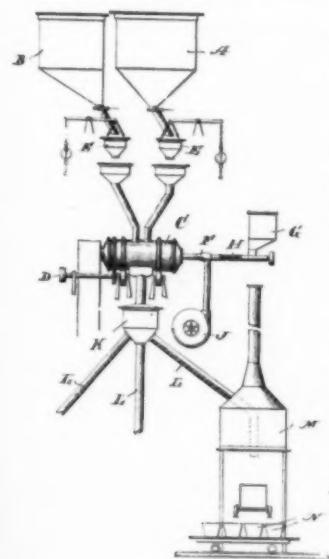


FIG. 1.—APPARATUS FOR MAKING CALCIUM CARBIDE.

(from bin *G*) and an air-blast, by means of the blower *J*. The furnace *C* is first heated to 1,500° to 2,000° F., and then the charge of limestone is introduced from *A*, and furnace *C* is slowly rotated. Carbonic acid gas and other gases are driven off, and the charge is heated up to incandescence. The charge of pulverized coke (1 part by weight for every 3 parts of limestone) is then introduced from *B* into furnace *C*, which is now rapidly rotated. During this "preheating operation" a small portion of carbide dust or fines may be added in order to thoroughly expel and drive off any remaining carbon monoxide and carbon dioxide.

From the preheating furnace *C* the charge is passed to the

distributing tank *K*, but in order to maintain the high temperature, a "superheating compound" is first added, which also serves for removing any phosphorus that may be present. This superheating compound consists of 60 per cent calcium carbide, 20 per cent black oxide of manganese, 15 per cent bituminous coal, 3 per cent aluminium and 2 per cent chlorate

of potash, all elements in pulverized or granular condition; 15 to 20 pounds of superheating flux are added per ton of material treated. The object is to maintain the charge at a sufficiently high temperature, so as to avoid the necessity of an expenditure of more electrical energy later on in the process.

From the distributing tank *K* the charge is delivered through one or more pipes *L* to the electric furnace *M*, where the charge is heated to the melting

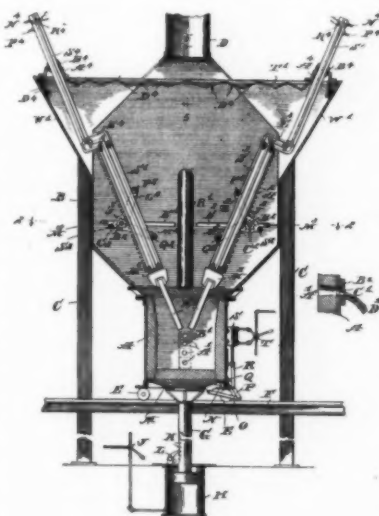


FIG. 2.—ELECTRIC FURNACE FOR CALCIUM CARBIDE.

point to effect the conversion into carbide, and finally tapped and run off into molds or over plates, so as to spread out into a comparatively thin sheet, so as to cool within a very few minutes' time. The object is to produce a carbide of a comparatively hard stone or flint-like structure, which is not objectionably porous, and which, during the crushing or breaking operation, yields a small percentage only of fines.

The molds are covered with coal-tar, glucose or the like, mixed with finely-divided coke. The object of the coal-tar or glucose is to apply to the carbide a thin superficial protecting coating, so as to protect it against moisture. The finely-divided coke is used to prevent the admixture of particles of metallic calcium to the mass of carbide. In the reaction with water any particles of calcium would yield hydrogen gas, which would detract from the illuminating quality of the acetylene gas.

The general construction of the electric furnace is shown in Fig. 2. One of the main objects is to permit adjustment of the voltage according to the amount of charge delivered to the furnace chamber or to the condition of the carbon electrodes. The carbons can be adjusted longitudinally, and the slant or inclinations of the carbons with reference to each other may be varied. *A* is the furnace chamber into which the charge is introduced so as to drop between the two electrodes. *A'* are the discharge openings, protected by slabs *B'*, the construction being clearly shown in the small diagram at the right-hand of Fig. 2. For further details of the furnace construction see patent 819,224. The lining for the electric furnace (patent 819,223) is made by "mixing together cream of lime and pulverized coke and then adding thereto a mixture of asbestos and a hydrocarbon adherent, then forming the same into bricks, blocks or slabs, and then pressing and drying the same."

Tantalum.—W. von Bolton, 817,733, April 10. Application filed Jan. 5, 1904. (Assigned to Siemens & Halske Co.)

An impure amorphous powder containing oxides or carbides of a highly refractory material, such as tantalum, is reduced to the pure metal by the heat of the electric arc in a vacuum furnace. "Prior to my invention, so far as I am aware, there did not exist a relatively pure metal of a highly refractory type, such as tantalum, which was ductile or capable of being rolled or drawn, and such a product being new with me constitutes the essence of my improvement." The two claims are exceedingly broad; the first one reads: "A metal derived from tantalum compounds and possessing the quality of being homogeneous and ductile;" the second: "substantially pure metallic tantalum possessing the qualifications of homogeneity and ductility."

Reducing Calcium Oxide.—T. L. Willson, 820,031, May 8. Application filed Jan. 28, 1896. (Assigned to Union Carbide Co.)

It took more than ten years to get this patent granted. It refers to the reduction of calcium oxide in an electric arc furnace, a carbon crucible serving as one electrode and a carbon pencil as the other one. The charge is calcium oxide and coke. "The reduced metal may alloy or combine with some other metal or element if present and may combine with an excess of carbon to form a carbide."

Electric Furnace for Iron Reduction.—M. Ruthenburg, 818,918, April 24. Application filed Nov. 28, 1903.

Mr. Ruthenburg's process for treating iron concentrated from magnetic separators has been repeatedly described in our columns (see the index of our former volumes under *Furnace, Electric, Iron and Steel, Ruthenburg*). The present patent relates to the combination of the different stages of the process. First, the comminuted particles of ore are fritted together in coherent porous lumps by passing the concentrates between two revolving rolls which serve at the same time as electrodes. The lumps drop into a reservoir below, with a confined heated atmosphere. Then before the lumps have fallen below the temperature of reduction of iron oxide, they are subjected to the action of a reducing gas from a gas producer, and are then reduced without being fused. By applying more electrical heat the reduced metal is melted and drawn off. Under the conditions of the experiments of the inventor the fritting operation required 100 volts, and the smelting of the reduced iron about 15 volts. The two sets of electrodes used for both operations are connected in series.

Fusing Quartz.—C. O. Wingren, 817,212, April 10. Application filed Aug. 21, 1905.

In making articles of fused quartz in an electric furnace, the difficulty has often been experienced that after cooling the quartz contains air bubbles. These are due to lack of fluidity in the quartz, this being not sufficient to expel the air. The inventor connects his electric furnace with an air pump, and, while melting the quartz, he puts a pressure on the quartz;

after the quartz is melted he exhausts the air from the furnace; finally he places again a pressure upon the mass while it is cooling. The claims refer to the construction of the furnace and pump.

Electric Muffle.—E. Zell, 819,625, May 1. Application filed Oct. 28, 1902. (Assigned to General Electric Co.)

Iron is a very suitable material for walls of muffles, heated by the passage of an electric current through the walls, but the iron must be protected, as it would quickly corrode and deteriorate otherwise. The inventor packs the iron in granular calcium carbide. The action of the heated chamber on the packing is to produce carbon monoxide and calcium oxide,

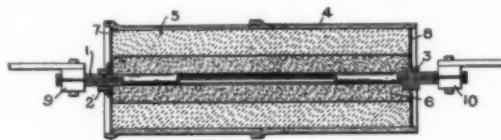


FIG. 3.—ELECTRIC MUFFLE.

both serving to protect the tube. "With such a packing an iron-chamber furnace can be run at a temperature of about 1,000° C., and the life of the chamber is of considerable duration." In Fig. 3 the iron pipe 1, threaded at both ends for making connections, forms the heating chamber. Around it there is the packing 6 of granular calcium carbide, and around this a lining 5 of lime or asbestos.

Dental Furnace.—J. F. Hammond, 817,767, April 17. Application filed April 13, 1905.

The interior of the muffle is wound with a heating platinum wire. A resistance wire of nickel is wound around the casing for the muffle. Both wires are electrically connected. The convolutions of the resistance wire of nickel are so bent, at portions parallel to each other, that the bend of one wire will lie within the bend of another wire. A sliding contact is provided along these bends for varying the resistance. In this way the amount of heat generated can be easily controlled. The furnace is specially adapted for the manufacture of jewelry and dental articles.

Dental Furnace.—D. G. Steinecke, 820,025, May 8. Application filed May 23, 1905.

Details of construction of a dental furnace, intended to be an improvement on the "Hammond furnace." The muffle is composed of two parts, and is readily detached from the furnace proper. Each of the two parts of the muffle may be electrically heated independent of the other part.

ELECTROLYTIC PROCESSES.

Smelting Lead Ores.—W. Valentine and A. G. Betts, 816,764, April 13. Application filed June 15, 1904.

The process described in this patent was fully and authoritatively covered in the article of Mr. A. G. Betts in our May issue, page 169. Claim 1 relates to "the process of recovering lead from lead-sulphide ores, which consists in fusing the ore and accompanying gangue into a matte and a slag, and electrolytically separating lead from the matte by bringing the matte into contact with a cathode in a fused electrolyte in which lead sulphide is substantially insoluble."

Electric Furnace.—A. G. Betts, 816,554, April 3. Application filed May 20, 1904.

Details of construction of the furnace which was described and illustrated (Fig. 2, p. 171) in Mr. Betts' article in our May issue.

Electrolytic Production of Caustic and Chlorine.—F. McDonald, 814,864, March 13. Application filed April 27, 1905.

The inventor, who has been quite active in this field in recent years (our Vol. I., p. 387, and Vol. III., p. 116), patents

the arrangement of plant shown in Fig. 4. The solution of sodium chloride is fed through pipe 20 to the anode compartment of the electrolytic cell 1. This supply is controlled by the valve 23, which is in turn controlled by the float 23', mounted in a tank 21. This is in communication with the bottom of the anode compartment of cell through pipe 22, so that the level of the brine solution is the same in the anode compartment of 1 and 21. The overflow pipe 30 leads to the gas-collecting pipe 31, into which the overflow of the anode compartment of

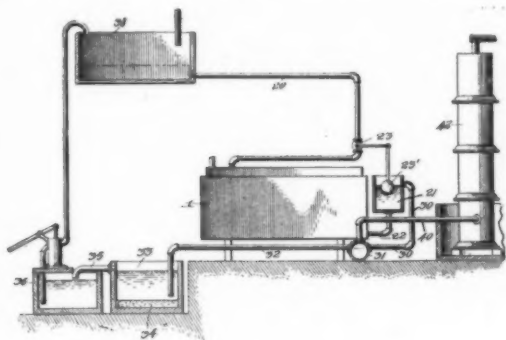


FIG. 4.—APPARATUS FOR ELECTROLYSIS OF SODIUM CHLORIDE.

each cell 1 discharges. The weak brine discharged into 31 is maintained in this pipe at a constant level, there being sufficient space above it to permit the chlorine gas to collect. The weak brine is discharged from 31 through 32 into the resaturating tank 33, which contains salt. The solution flows over to 36, from where it is pumped to 38. The chlorine gas is conducted from 31 through 40 to a series of absorbing towers 42, through which it passes in a circuitous course while being absorbed by lime water.

Electrolytic Manufacture of Metal Tubes.—O. Dieffenbach, 817,419, April 10. Application filed January 9, 1906.

Prof. Dieffenbach makes copper or nickel tubes by electrolytic deposition on a revolving horizontal or inclined cathode. He adds to the electrolyte a porous granular inert material. The rotary movement of the cathode carries this material upwards on one side, and lets it slide down again on the other side. By impinging against the cathode this material removes any small adhering bubbles of hydrogen and smoothes the deposit. The only suitable material of this kind for making tubes of any desired dimensions is kieselguhr.

Chlorine and Phosphate.—A. Clemm, 819,410, May 1. Application filed Feb. 27, 1905.

Phosphate—as, for instance, Florida-Algier phosphate—bones or the like, are treated with hydrochloric acid, and the solution of phosphate is separated from the residue and any excess of hydrochloric acid is neutralized, until a precipitate begins to form at the surface. This solution of acid phosphoric acid salt and metal chloride is subjected to electrolysis. Chlorine is evolved at the anode, and at the cathode hydrogen is evolved, and a precipitate of phosphate ($\text{Ca}_3\text{H}_2\text{P}_2\text{O}_8$) is formed. This precipitate of phosphate is completely and readily soluble in a 2 per cent solution of citric acid. The composition of the liquid to be electrolyzed may be changed; for instance, one may mix together a solution of acid calcium phosphate with chloride of calcium (or chloride of magnesium or the like), the electrolysis of which gives the same result. The first mode of working is especially applicable where greater quantities of hydrochloric acid can be had at low cost, and the second where chloride of calcium or chloride of magnesium can be obtained at low cost, as by-products or waste, and where a solution of acid calcium phosphate, such as that obtained in the extraction of low-grade phosphates, by treating the latter with

dilute sulphuric acid, can be produced more cheaply than by treating them with hydrochloric acid.

Production of Ammonia.—J. A. Lyons and E. C. Broadwell, 816,928, April 3. Application filed Sept. 2, 1904.

Fig. 5 shows the crucible *A* forming the cathode and the anode *C* of carbon in the center within a pipe or annular jacket *D* of graphite, which serves as a diaphragm. The arrows *E* indicate the course of the current. The borate of any of the positive metals or a mixture of the same (borates of potassium, sodium, manganese, chromium, etc.) are maintained in fusion in the crucible. The passage of the current produces electrolysis and generates an intense heat at the carbon anode, due to the high anodic current density. At the same time nitrogen gas or nitrogen-bearing gases are passed from the vessel *F* into the bath through the annulus or pipe *D* around the anode. "The electrolysis produces anion, boric anhydride and oxygen at the anode, where the intensely heated carbon acts as a reducing agent to chemically reduce the anion to boron. The pipe serves to prevent the boron thus formed from floating over to the cathode, and the nitrogen introduced into the pipe combines with the boron to form boron nitride. The metal of the borates will be deposited at the cathode." After sufficient boron nitride has accumulated it is subjected, while separated from the metals, to steam, at a temperature of 600° C., or above, yielding boric anhydride and ammonia, according to the reaction:



The temperature of the bath is maintained at about 1,000° C.

Electroplating Tank.—C. G. Backus and G. L. Wallace, 817,832, April 17. Application filed July 27, 1905. (Assigned to Zucker & Levett & Loeb Co.)

The patent refers to a convenient and cheap electroplating tank with a rotatable receptacle containing a large number of articles to be plated at the same time. The left-hand diagram of Fig. 6 shows the complete apparatus, the drum being

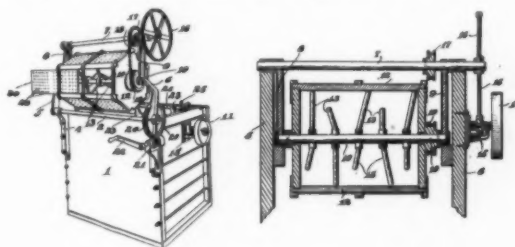


FIG. 6.—ELECTROPLATING TANK.

raised to be charged with the articles to be plated. The right-hand diagram shows the interior of the drum and the way in which it is mounted. The apparatus is very convenient to handle in electroplating practice. Its operation is obvious from the illustrations.

Nickel Plating.—J. W. Aylsworth, 817,152, April 10. Application filed Sept. 17, 1904.

This patent refers to improvements in his former process (described and illustrated in our Vol. III, p. 114) for nickel plating of long perforated strips of thin sheet iron or steel (which are subsequently cut up into blanks for use in the Edison storage battery). In his old process one step is the passage of the strip through a chamber in which it is sur-

rounded by hydrogen gas and is heated by the current, or otherwise to a welding temperature, so as to cause the nickel film to be welded in place to remove any condition of tension therein. The inventor has now found that this is not necessary as a part of the plating process, and that superior results can be secured by placing a large number of the reels carrying the nickel-plated strips thereon in a muffle in which they are heated to a welding temperature in the presence of hydrogen gas, since in this way the operation can be very economically performed.

Electrolytic Decomposition of Water.—W. F. M. McCarthy, 816,355, March 27. Application filed Nov. 8, 1904.

Two receptacles, each containing one electrode, are connected by a conduit near the bottom. Each electrode is a plate of platinum coiled upon itself a number of times and has a projecting terminal portion directly opposite the end of the conduit. See also his former patents noticed on pages 113 and 192 of our March and May issues.

Water Purifier.—F. B. Hinkson, 820,113, May 8. Application filed May 31, 1905.

Claim 1 reads: "In a water purifier, the combination with a shell or casing having a water-inlet at one end and a water-outlet at the other end, of a series of annular electrodes located within the shell or casing and disposed, one within another, means for insulating said electrodes from each other and from the shell or casing, and electrical conductors connected, respectively, within the inner and outer electrodes."

Electrolytic Purification of Liquids.—L. Dion, 819,209, May 1. Application filed June 3, 1904.

Details of construction of apparatus for purifying a liquid by passing it between groups of positively and negatively charged electrodes.

ELECTRIC DISCHARGES.

Electric Discharges Through Air.—J. E. Mitchell and D. Parks, 817,082, April 3. Application filed Jan. 3, 1906. (Assigned to Alsop Process Co., St. Louis, Mo.)

The apparatus consists essentially of an electrifying chamber, two pump cylinders and an induction coil. In the middle of the electrifying chamber a stationary horizontal rod is provided, which is connected to one pole of the electricity supply. In line with this rod and on either side of it two movable electrodes are provided, which serve as the other electrode. These movable electrodes get a reciprocating movement by being mechanically connected with the piston rods of the pump cylinders which pump air into the electrifying chamber. Alternately one or the other of the movable electrodes makes contact with the corresponding terminal of the central stationary electrode. By breaking this contact an electric discharge takes place through air, while simultaneously air is pumped through the chamber. The machine is claimed to be compact, simple and durable and adapted to operate at a high rate of speed.

Bleaching and Sterilizing.—S. Leatham, 816,482, March 27. Application filed July 16, 1904.

In order to bleach flour, cotton yarn, etc., or to sterilize milk or food products, the inventor passes air successively through two apparatus, in one of which it is subjected to the action of a silent electric discharge (yielding chiefly ozone), and in the other one to a spark discharge. Both the ozonizer and the sparking apparatus are operated from the same electric circuit and are connected in series.

Apparatus for Indicating the Character of Electric Effluvia.—L. Gerard, 818,534, April 24. Application filed June 14, 1905.

In the production of electric effluvia (for producing ozone, etc.) the efficiency of the operation depends upon the character of the effluvia. They may be best studied according to the inventor by shunting the discharge-gap by a vacuum tube and subjecting the rays emitted from the vacuum tube to physical analysis and observation (by spectroscopic methods, etc.).

BATTERIES.

Alkaline Storage Battery.—T. A. Edison, 817,162, April 10. Application filed Sept. 29, 1904.

In the Edison iron-nickel cell the negative active material when charged consists of a mixture of reduced iron and mercury. When the cell is shipped in this condition, the electrolyte being removed, the iron becomes oxidized, generating heat and driving off more or less mercury. This reduces the capacity of the plate. To safely ship the cell without electrolyte, the negative plate should be completely discharged, so that the iron is fully oxidized and no atmospheric oxidation can take place.

Alkaline Storage Battery.—T. A. Edison, 821,032, May 22. Application filed Sept. 28, 1904.

In the practical use of his iron-nickel battery, Mr. Edison found that bulk for bulk finely divided iron, obtained by reducing ferric oxide, is much more active electrolytically than the nickel hydroxide which he has so far been able to obtain practically. Consequently to present the best combination for practical use, the bulk of iron used need be only half that of the nickel. He uses pockets of the same size for both the nickel and the iron active materials, but uses twice as many nickel grids as iron grids. No insulating separators are required between adjacent nickel grids, which may therefore be allowed to swell, so as to touch each other without affecting circulation and the general operation of the cell.

Storage Battery Plate.—J. R. Macmillan, 817,498, April 10. Application filed April 1, 1905.

In claim 1 the inventor claims "in a storage-battery grid unit the combination of an inclosing frame, a plurality of horizontal ribs extending across said frame, a plurality of transverse ribs extending across said frame and intersecting said horizontal ribs to form compartments for lodgment of active material, projections on said transverse ribs extending into said compartments, said ribs and projections being quadrilateral, the top and lower edges thereof being disposed in a common vertical plane, and a web on said ribs and projections disposed in said vertical plane."

Battery Plate.—O. H. Fay, 820,040, May 8. Application filed Aug. 19, 1904.

Details of construction of the grid for battery plates of the Faure-Brush type. Claim 1 reads: "A battery plate, comprising end bars, a series of longitudinal bars provided with a series of rearwardly-flaring grooves, and a series of strips extending across the opposite faces of the plate, and in staggered relation to each other."

Storage Battery.—W. H. Palmer, Jr., 817,132, April 3. Application filed Feb. 14, 1905.

Details of suspension and connections of the positive and negative plates, alternately arranged.

Dry Battery.—C. J. Hirlimann, 820,047, May 8. Application filed May 25, 1905.

"A dry battery comprising a zinc cup or outer casing containing absorbent material, a carbon element therein having a straight cylindrical hole throughout its length and having narrow radial slots in the wall thereof, said slots extending from a point near the top of the carbon element to a point near the bottom thereof and of a width insufficient to permit the entrance of the sawdust or similar material therethrough, whereby the exciting material or reagent may be run into the hole to fill the same and afterward pass through the slot to impregnate the absorbent material to a predetermined degree of saturation, and a stopper or closure inserted into the upper end of the hole in said carbon element."

Binding Posts.—J. D. Warren, 819,389, May 1. Application filed May 2, 1905.

Mechanical details of connecting the electrodes of batteries with binding posts.

SYNOPSIS OF PERIODICAL LITERATURE.

THEORETICAL AND EXPERIMENTAL.

Osmosis.—The March issue of the *Journal of Physical Chemistry* contains a long and elaborate paper by L. Kahlenberg on the nature of the process of osmosis and osmotic pressure with observations concerning dialysis. The main conclusions are that whether osmosis will take place in a given case or not depends upon the specific nature of the septum and the liquids that bathe it; and if osmosis does occur these factors also determine the direction of the main current and the magnitude of the pressure developed. The motive force in osmotic processes lies in the specific attractions or affinities between the liquids used, and also those between the latter and the septum employed. These attractions or affinities have also at times been termed the potential energy of solution, etc., they are to the mind of Prof. Kahlenberg essentially the same as what is commonly termed chemical affinity. It has been emphasized that osmotic pressures are equilibrium pressures, and that in osmotic processes there is always a current in both directions, though the main current may in specific cases be so much stronger than the minor that the latter almost sinks into insignificance. In such cases the septum employed is termed "semipermeable." Vulcanized caoutchouc is a "semipermeable" membrane when it separates pyridine solutions of silver nitrate, lithium chloride and cane sugar from the pure solvent. The necessity of stirring the contents of the osmotic cell and also the outer liquid during osmotic pressure measurements is pointed out, and a new apparatus for measuring osmotic pressures accordingly has been devised. The results of the osmotic pressure measurements show that the gas laws do not hold; and it is, consequently, pointed out that the latter cannot serve as a basis for a satisfactory theory of solutions. The advantage of stirring-in processes of dialysis is indicated, and it is shown that whether substances pass through membranes or not does not depend upon their colloidal or crystalloidal character, but solely upon their affinity for the membrane employed, and for the liquids that bathe it.

A New Way of Fixing Doubtful Atomic Weights.—In a recent lecture by Prof. J. J. Thomson, before the Royal Institution in London, on the corpuscular (electronic) theory of matter, reference was made to the remarkable discovery that if the secondary radiation emitted by elements under the influence of Roentgen rays be measured by the ionization it produces within a millimeter of the surface of the substance, numbers are obtained that rise steadily with the atomic weight. If the ionization be plotted on an atomic weight base, a curve of such definiteness is obtained that it may prove useful in the future in fixing doubtful atomic weights.

METALLURGY.

IRON AND STEEL.

Blast Furnace Practice.—Director Oskar Simmersbach contributes a well-illustrated series of articles to *Stahl und Eisen* (March 1 and 15, April 1 and 15), on recent advances in this line. His descriptions of apparatus, however, are mostly confined to those in European practice, which are rather behind than ahead of the best American practice. Some of the most interesting items are the following: The method of opening up a frozen tap-hole by means of oxygen at 30 atmospheres pressure, is gaining in popularity. The frozen iron is first heated to redness by an oxy-hydrogen flame, then subjected to the oxygen blast alone, which burns iron, silicon, carbon, phosphorus and manganese to such good effect that each kilogram of material burnt will melt 4.5 kilograms of solid material. Holes a meter long can be melted in about 1 minute, in solid iron, at small cost. Opening a frozen tap-hole in this manner costs usually \$0.75 to \$1.25, seldom as much as \$2.50. Copper or bronze are not injured by the oxygen blast. At Pont-à-Mousson the workmen (perhaps rather *strikermen*) suddenly walked off on strike, leaving five blast furnaces in

full operation. They were at once banked, and on again resuming three started all right, the fourth had frozen iron in the tuyeres, the fifth had frozen iron up to 1.5 meters above the tuyeres. Dr. Menne's oxygen specific was called into action, an ironmaster from Creuzthal melted out every tuyere of furnace number, four in short order, and it went into blast at once. The fifth furnace was, however, more nearly deceased; temporary tuyeres were opened up above the "sow," and then the iron melted out at a lower point. The melting was repeated at lower and lower points in the crucible, until on the fifth day the normal tap-hole was in operation, the normal tuyeres were melted out and started, and this *Lazarus* of blast furnaces was transacting business at the old stand. The remedy for the two furnaces was twenty-six "bottles" of oxygen, costing altogether \$65.

Creuzthal has further distinguished itself, in the person of Director Dresler, by "banking up" a blast furnace fifteen months, and then having it in normal running order in 4 hours after putting on hot blast. The method is simplicity itself (when you know how); the furnace is simply allowed to "go out," and it might stay out fifteen years if necessary, and start up just as promptly. As for details, the hearth is emptied, the charge line allowed to sink a little, and then the top of the charges covered with sheet iron, and a layer of wet clay stamped in on top until the furnace charge is shut up hermetically, when the bottom openings are also closed. Then one waits until the strikers come to reason, or a new iron-ore district is discovered, or a new ministry comes in and changes the tariff—and then the clay is dug out, the sheet iron removed, the tuyeres opened, hot blast turned on, and in 4 hours—*viola*.

Director Simmersbach finally discusses Gayley's dried blast, without developing anything new, and, in fact, without thoroughly understanding the question in all its bearings. But, afterwards, he closes with some remarks on the possibility of using air blast richer in oxygen, which are very much to the point. He points out that blast richer in oxygen would result in a higher temperature before the tuyeres, an easier reduction of silicon, a gas richer in carbonous oxide (CO), a quicker reduction of the charge, a larger proportion of CO in the gases (this prediction is just the opposite of what would occur), economy in fuel and increased output. With the parenthetical exception just made, we agree with all of these predictions; it only remains to enrich the blast in oxygen at a cost less than the money value of the above catalogued advantages.

Blast Furnace Profiles.—Prof. Bernhard Osann, of Clausthal, delivered an interesting lecture on this subject before the Southwest Luxemburg Ironmasters on March 18, which is reported in full in *Stahl und Eisen* for April 15. From a comparison of many modern blast furnaces the following general dimensions are deduced as those found best by experience:

Output in Metric Tons Per Day	Diameter of Hearth Meters	Depth of Hearth Meters	Height of Tuyeres Meters	Height of Slag Line Meters	Diameter of Throat Meters
40-60	2-2.5	1.5	1.2-1.3	two	3.5-3.8
60-150	2.5-3.5	up to 2.0	1.3-1.8	thirds	3.8-4.9
150-350	3.5-4.0	2.5	1.3-1.8	height of	3.8-4.9
350-600	4.0-4.7	3.1	1.8-2.6	tuyeres	3.8-4.9

In all modern furnaces the angle of the boshes is close to 75° or 76°, and the inclination of the shaft walls above 86°. Calling r the radius at the top of boshes, r_1 at the bottom of boshes, r_2 at the throat, and h_1 the height of the bosh, h_2 the height of the shaft, then

$$h_2 = 4 (r - r_2)$$

$$h_1 = 14.3 (r - r_1)$$

and the volumes of the shaft and boshes together are

$$V = 1.05 h_2 (r_2^2 + r^2 + r_1 r_2) + 1.05 h_1 (r_1^2 + r^2 + r_1 r_2)$$

This facilitates very much the calculation of cubic contents of boshes and shaft, which are the effective volume of the furnace. The time of treatment of a furnace full of material (*Durchsatzzeit*) varies from 24 hours down to 10, the latter

only attainable by high blast pressure, good strong coke and when not making a high silicon iron. The lecture contained many other generalizations, but they apply only to regular practise with regular ores, so that the results possess no exact value for general application.

Cementation.—Dr. Eng. R. Bruch describes in *Metallurgie* for February 22 his very carefully conducted investigation of the cementation of wrought iron by gaseous carbonizing reagents. A bar of wrought iron 70 m. m. long by 11 m. m. diameter was heated in a porcelain tube, in each test for 7 hours, at temperatures of 600, 700, 800, 900, 950, 1,000, 1,050, 1,100, 1,150 and 1,200° C. The bar was afterwards turned off in five successive layers of 0.5 m. m. thickness each, and each carefully analyzed for carbon. The wrought iron contained 0.03 carbon, 0.023 silicon, 0.035 manganese, 0.014 phosphorus and 0.008 sulphur. The various tests resulted as follows: *Illuminating gas* (containing 33 per cent. CH₄ and 3.5 per cent. higher hydrocarbons) showed practically no carbonization below 700°, slow carbonization (up to 0.5 per cent.) up to 1050°, and rapid cementation (up to 1.5 per cent.) between 1050° and 1100°. *Petroleum vapor* showed slower carbonization, practically none at 700°, up to 0.25 per cent at 1050°, and rapid carbonization up to 1.5 per cent. between 1050° and 1100°. *Acetylene* showed very little carbonization below 900°, 0.25 per cent. at 950°, 0.6 per cent. at 1000°, 0.8 per cent. at 1050°, and 1.2 per cent. at 1100°. The strong carbonization commences sooner than with the first two reagents. Carbonous oxide gas (CO) produced no carbonization at all, in 7 hours, at temperatures between 500° and 1100°. The net conclusion is that illuminating gas, petroleum vapor and acetylene all act strongly carbonizingly on iron, very slightly at 700°, faster at 900°, and fastest at 1050° to 1100°; that the process is one of solution and diffusion of the carbon in the iron, and that it is being utilized practically on an extensive scale.

Graphitic Carbon in Cast Iron.—Engineer J. Kreiten gives us in *Metallurgie* for March 22 the results of tests to show the influence of tin on the separation of graphitic carbon in cast iron. Up to 3 per cent. of tin was added. In irons containing 3 per cent. and 1.3 per cent. of silicon, in which graphitic carbon was 70 per cent and 64 per cent of the total carbon, the effect of tin up to 3 per cent was negligible—that is, it did not practically increase the graphitic carbon. With 0.01 per cent of silicon present, the effect of tin was small until it exceeded 1 per cent. At 1.25 per cent of tin, 7 per cent of the total carbon became graphitic; at 1.81 per cent tin, 10 per cent; at 2.86 per cent tin, 37.3 per cent, or over one-third of all the carbon, became graphite. Higher percentages of tin lowered the total carbon, as well as the graphite, the former faster than the latter.

In *Metallurgie* for April 8, F. Wüst describes similar tests on the effect of sulphur. This element reduces the total per cent of carbon present, and strongly reduces the amount of graphite. With 0.6 per cent sulphur, even an iron with 2 per cent of silicon contained only 0.12 per cent graphite. Phosphorus, however, was shown to strongly increase the formation of graphite when it exceeded 2.5 per cent; in an iron with 0.1 per cent silicon, 6 per cent of phosphorus increased the graphitic carbon from 0.07 to 1.82 per cent; in an iron with 0.9 per cent of silicon, phosphorus up to 3 per cent had no effect, but above that increased the graphite per cent about 0.25 per cent for 4 and 5 per cent of phosphorus.

SILVER.

Alloys with Arsenic.—K. Friedrich and A. Leroux have studied these alloys in the Freiberg Academy laboratory and report their results in *Metallurgie* for March 22. They found it possible to get alloys with 25 per cent of arsenic, which, however, fell to 19 per cent while cooling slowly when melted. The cooling curves of all the alloys tested were very simple; an upper setting point and a lower resting point, the former gradually falling from 962° to 527° as the content of arsenic

increased towards 25 per cent., the latter being constant at 527° for all the alloys, and therefore corresponding to a eutectic with probably 25 per cent of arsenic, and melting at 527°.

RECENT METALLURGICAL PATENTS.

REDUCTION OF FINELY DIVIDED ORES.

Two patents of the late Horace F. Brown (817,414 and 817,415, April 10) refer to his process for reducing of finely divided ores of iron, copper, lead and zinc, such as flue dust, mill dust, fine concentrates, oxide of iron sands and the like. The ore is first fed into the upper part of a vertical stack, there subjecting the particles while in suspension, and in a more or less segregated state, to the action of a reducing atmosphere moving in the same direction as the ore, whereby the latter is reduced, the particles being at the same time brought "into approximate physical contact." If necessary, this stack may contain two chambers, one above the other, of which the upper one carries a very high temperature with little or no reducing atmosphere, while the lower chamber contains an excess of reducing gas. It is vitally necessary that after reduction and before the second step of the process—separation of the reduced metal from the gangue—the metal shall be protected from contact with an oxidizing atmosphere or reagent. For this purpose the excess of reducing gas is provided at the bottom of the stack.

The deoxidized metal falls from the stack into a fused bath in a reverberatory furnace or forehearth, where it is protected against oxidation by a cover of molten slag while being further heated to complete fusion. On account of the differences of specific gravity the metal is separated here from the gangue, which goes into the slag. The reducing gas is mixed over the surface of the gas with an excess of oxygen to further its combustion and heat the bath. In practice carbonating and slag-producing ingredients may be fed with the ore to the stack if desired.

Iron-Sand Reduction.—As applied to the treatment of iron-sand the process is as follows: In this case a comparatively high temperature is required for the reduction of the iron oxide, and the stack, therefore, contains two chambers, as described above. The upper one is for preheating the rain of finely divided iron oxide and silica particles with an excess of lime to a temperature in which the iron oxide is ready for deoxidation. The reduction begins at the lower end of the upper chamber and is completed in the lower chamber, while the lime combines with the silica and alumina of the charge, forming a silicate of lime and alumina. The iron reaches the lower end of the stack as metal. The excess of lime forms a basic slag, so that when the reduced iron is once beneath the surface of the bath it is protected from oxidizing action.

Treatment of Lead and Copper Oxide Fines.—In this case a lower temperature is to be maintained than in the case of iron. While descending through the stack the impurities are formed into a slag, of which iron, silica and lime form the main constituents. The reducing gases and the heat are so regulated that the iron is not deoxidized, but unites with the lime and silica, forming a slag of silicate of lime and iron, while the oxides of lead or copper are reduced to the metallic state.

FLAME REGULATION.

The "Eldred Flame."—Our readers who are well acquainted with this subject from the articles of Mr. Ellis (our Vol. II., p. 495) and Mr. McElroy (p. 141 of our present volume) will be interested in two recent patents granted to Mr. B. E. Eldred. One (819,045, May 1) refers in its second claim to "the art of heating materials in furnaces of the reverberatory type, which consists in transmitting through a body of ignited fuel a draft-current of air diluted with products of

combustion in such proportion as to check and cool the combustion of such fuel and to retard combustion of its gaseous products, passing said gaseous products into a refractory-wall chamber containing the material to be heated and there completing their combustion by radiant heat from the walls." The other patent (819,046, May 1) refers to means for controlling the gas velocity in reverberatory furnaces in which several fire-boxes are employed. The reverberatory furnace is provided with a plurality of successive flame-introducing means at different points along its hearth chamber, so as to successively increase the flame volume. Beyond each such flame-introducing means the internal diameter of the hearth chamber is increased to correspond to the increased volume of flame.

ROASTING FURNACES.

McDougall Roasting Furnace.—The work done by Mr. Frank Klepetko in recent years with respect to details of construction of the McDougall type of ore-roasting furnace is well known to our readers. Three patents recently granted to him refer to modifications of constructions patented by him before. In the first patent (814,297, March 6) he proposes to introduce the cooling medium into the hollow rabble shaft at a point where in the majority of cases the furnace is hottest. This is the middle of the furnace, the upper hearth being cooled more or less by the introduction of the charge and the bottom hearth receiving the material after its fuel contents has been consumed during the roasting operation. Under these conditions the introduction at the middle point results in the formation of two distinct currents of the cooling medium, one ascending and the other descending, suitable outlets for the discharge being located at opposite ends of the rabble shaft. The shaft is provided with a series of hollow rabble arms (each series extending into its corresponding hearth), and is divided into distinct compartments communicating with the arms; it follows that the currents of the cooling medium will be parallel in opposite directions along the shaft, and so far as the arms are concerned the circulation will be vertically in series through the arms and radially in multiple. The resulting circulation, therefore (from the point of introduction in the shaft), through the shaft and arms will be vertically "in parallel" and "in series," and radially "in multiple."

The second patent (814,298, March 6) proposes to provide the hollow rabble shaft with longitudinal division walls or diaphragms dividing the passage of the shaft into two or more independent conduits for the circulation of independent currents of cooling mediums, so that in the event of a leak or puncture of the walls of one of the conduits the remaining conduits may not be affected, thus obviating the necessity of an immediate shut-down of the furnace. The diaphragms also permit of the introduction of cooling mediums from independent sources, so that water may be made to circulate through one or more of the conduits and air through the balance, etc.

The third patent (814,294, March 6) refers to the division of the rotary furnace into a series of sections or compartments corresponding to the number of hearths of the furnace, each section being cooled independently of any adjacent section by means of a circulating medium injected from a common source of supply; the circulating medium is discharged from each section or compartment into a common return pipe or outlet leading from the furnace. The advantage of such a construction is that the circulating medium may be cut off for such hearths in which there is no longer any danger or injury to or destruction of the rabble apparatus from the heat inherent in the charge contained in the hearths.

GOLD AND SILVER.

Refining Finely Divided Hydrometallurgical Products.—In refining finely divided precipitates from cyanide, chloride or hyposulphite solutions or electrolytic deposits or residuum,

difficulties are experienced principally on account of dust losses. Charles W. Merrill (815,851, March 20) mixes the materials with litharge and adds a soluble lead salt and briquets the mixture. It is then fused in a cupel or crucible, whereby the litharge and soluble lead salt are reduced to metallic lead, fresh material being periodically added. The lead collects and contains the finely divided precious metals, and is then cupelled off and recovered as litharge, to be used in subsequent operations. A special advantage claimed for the process, besides preventing dust losses, is that the by-products are of very low value, for the reason that the lead is constantly percolating downward through the slag and carries the values with it.

Treating Ores Containing Selenium.—A process of A. C. Atwater (817,411, April 10) relates to the treatment of ores, of precious metals containing selenium, and is not confined to sulphide ores. The granulated ore is mixed with a theoretical amount of granulated carbon, so as not to have an excess of the latter. The mixture is placed in a crucible over which is placed a tight-fitting inverted crucible, which has a small hole in the bottom. The crucibles are then placed in a furnace, and commencing with a low degree of heat the latter is gradually increased to a clear red, and continued at a steady heat, say from 1 to 2 hours. The selenium is thereby driven off through the hole in the top. When no longer gases are escaping, the crucibles are taken from the furnace and the hole is tightly closed with fire-clay, to prevent oxygen from entering the crucible. When cold, the material is in a condition in which the precious metals may be readily recovered by amalgamation, cyanidation, etc.

Wet Process for Recovering Precious Metals.—John A. Just (820,000, May 8) proposes the following process for recovering gold and silver directly from the ores without preliminary roasting or chloridizing. The object is to convert the precious metals into oxides and simultaneously dissolve the oxides thus formed in a suitable acid to form soluble salts with that acid, then extract them with water or with an acid in which the salts will readily dissolve. The solution is then separated from the gangue or sands and the precious metals are recovered from the solution. The inventor uses sulphuric acid together with an oxygen salt mixed with the finely ground ore. The acid liberates oxygen from the oxygen salt, so that the oxygen will act in its "nascent state." As oxygen salts, oxide of manganese, native or artificial, potassium permanganate, sodium nitrate, lead peroxide and sesquioxide, red lead, etc., may be used. The chemical reactions are discussed at some length in the patent specification. Claim 1 refers to "the process of extracting precious metals from ores or materials containing said materials with nitrosulfonic acid."

NICKEL.

Nickel-Copper Alloy.—A. Monell (256,677, Jan. 30) patents the production of a copper-nickel alloy directly from the nickel-copper ores without previous separation of the nickel from the copper. Ore containing sulphides of nickel and copper is smelted, the resulting matte is Bessemerized and then calcined, to remove the sulphur and to leave the nickel in copper in the form of oxides. The oxides are reduced in a reverberatory furnace with carbon, so as to produce an alloy containing about two parts of nickel and one of copper. "Such an alloy is much cheaper to work and reduce into sheets than copper, and therefore affords a less expensive finished product, but equally non-corrodible, while it possesses about the same tensile strength and elongation as soft steel of the kind generally used for boiler plates." The alloy is "much stronger than copper, and is freely malleable, even when cast. It can be used for the manufacture of roofing-plates, ship-plates, castings, fittings, propellers and other uses where great strength and freedom from corrosion are required. It can also be used to advantage in the manufacture of non-corrodible boiler tubes."

BOOK REVIEW.

PHYSICAL CHEMISTRY FOR ELECTRICAL ENGINEERS. By J. Livingston R. Morgan, Ph. D. 12mo., VIII. 230 pages. Cloth, \$1.50 net. New York, John Wiley & Sons.

The contents comprise 15 pages on fundamental principles, 18 on the general properties of gases, 16 on heat and its transformations, 47 on solutions, 36 on chemical mechanics, 39 an equilibrium in electrolytes, 38 on electrochemistry proper, and 10 pages of problems for solution. The aim of the author has been to discuss "those laws and generalizations of physical chemistry which form the basis of the subject embracing the chemical application of electricity and the electrical applications of chemistry." The guiding principle of the author has been to avoid "the use of any hypothesis," to place the subject "upon an absolutely experimental basis," and to draw no inference "not justified in all its parts by actual results."

Our opinion of the work is that the author's aim has been very satisfactorily realized, that he has furnished the clearest possible introduction to the understanding of modern physical chemistry; and as such we recommend it most heartily to electrical engineers desiring to lay a good foundation for mastering electrochemistry. As far as the author's guiding principle is concerned, he has stuck to it bravely, but has slipped up by admitting some hypothesis (such as Nernst's solution-tension theory of metallic electrodes). However, the author's intentions were so highly commendable, and in greater part so admirably adhered to, that the few slips can be cheerfully excused.

Gas Power.

By OSKAR NAGEL, Ph. D.

It is the purpose of this article to explain the causes of the immense progress of the gas engine industry.

In selecting a motive power for large power plants in most cases steam and gas power has to be considered.

For the small manufacturer the selection of the most convenient motive power is very simple. The small size boiler plant has long ago been replaced by the illuminating gas engine, while for very small powers and discontinued use electric motors, driven with current from electric central stations, are used to a very large extent. Since the development of producer gas plants, which are entirely independent of illuminating gas plants, gas engines are used to great advantage for continuous use and larger powers.

Producer gas power plants, on account of their independence of illuminating gas plants, are of importance in districts where illuminating gas cannot be had, thereby replacing steam, oil and gasoline engines. The two latter kind, however, are to be recommended for portable machines and for places where discontinued work is carried on and where quick starting is desirable.

More difficult is the selection of a power plant for large industries. Ten to fifteen years ago gas engines were used only in exceptional cases for larger plants, especially in densely inhabited city districts. Some pioneers already at that time were strongly advocating the use of gas engines and producers. However, the steam engine naturally had more friends on account of the long established reliability, and on account of being much more considered in technical high schools than the new gas engine. The gas engine builder had many difficulties to overcome. But the reliability and economy of the gas engine was fully proved on a number of medium sized gas power plants; then the iron industries, having at their disposal a low-grade fuel gas—the blast furnace gas—especially adapted for driving gas engines, developed a demand for gas engines of immense size. While a few years

ago gas engines of 100 hp. capacity were considered as exceptionally large, we find to-day a large number of gas engines running having a capacity of several thousand horse-powers each.

On account of the much lower running expenses as compared to steam engines of equal size, the gas engine has attracted wide attention of parties interested in large power plants. In small plants the difference in cost of running is very great, somewhat smaller in larger plants, but even there very considerable.

The utilization of heat in the gas engine is very much higher than in the steam engine, which is the main cause of the saving in running. Furthermore, the generation of gas in producers entails considerably less loss than the making of steam. In illuminating gas engines the constant readiness and convenience is of advantage. But in all gas power plants the supervision of boiler plants is done away with and also the smoke nuisance.

The first experiments for burning gas in engines were made in the first half of the nineteenth century. Lenoir, a Frenchman, was the first who built a practicable machine, however, without compressing the air-gas mixture. In 1875, Otto built the first four-cycle machine, which, however, was not used at that time. A watchmaker in Munich had built a four-cycle engine several years before Otto.

Four-cycle is called the alternate use of the same cylinders once as pump for drawing in and compressing the gas-air mixture and then as power cylinder and for driving out the exhaust. One impulse takes place at every fourth stroke (cycle).

In the beginning 30 to 45 pounds of compression was applied and 35 cubic feet of gas required to develop 1 hp-hour. Later on the compression was increased so that at present in the smallest engines only 50 per cent of the above-named quantity of gas is required. In larger engines only 40-35 per cent is used, and the efficiency increased to about 36 per cent, while in large steam engines 16 per cent is considered to be the best result.

Afterwards the gasoline and oil engines were developed. Gasoline, on account of the easy combustion with the air is very convenient, while the handling of oil is more complicated.

The above-mentioned gas producers were first built by Dawson. Hard fuels, as, for instance, anthracite or coke, are very well adapted for use in these producers; bituminous fuels, on account of their tar contents, require a more complicated arrangement.

If fuel is charged into a shaft furnace (producer), lit and air blown through the fuel, a combustion takes place first of all to carbon dioxide. In going through the upper fuel layer carbon dioxide is reduced to carbon monoxide, which is a combustible gas, and forms the main part of the so-called producer gas. The other components of this gas are nitrogen and small quantities of carbon dioxide, hydrogen and hydrocarbons.

Such producer gas is used in the industries to a very great extent, and is made as a by-product in all blast furnaces, which are, in fact, huge gas producers.

By adding steam to the gasifying air, the gas gets richer in hydrogen and thermal value, by the decomposition of steam into hydrogen and oxygen. The oxygen forms with the carbon carbon-monoxide, and thereby decreases the amount of air and of the inert nitrogen to be introduced into the producer. Furthermore, the producer is running cooler and lasts longer.

One pound of carbon yields about 84 cubic feet of gas of 145-150 B. T. U., which is an efficiency of 80-90 per cent, a result which cannot be approached with steam boilers. This combined with the greater efficiency of the gas engine, causes a great decrease in fuel consumption as compared to steam plants.

In the first producer gas plants an independent boiler was used for furnishing steam to the steam jet blower. The firing

of this boiler means a loss in fuel, which, however, is equalized by preheating the combustion air by the hot gas which leaves the producer.

Efforts were made to do away with the boiler and to generate the steam in a vaporizer heated by the hot producer gas. Such plants have been largely introduced, especially in the so-called suction gas producer plants.

In these plants the gas engine draws the air through the producer by sucking the gas through the plant. A negative pressure prevails in the system, so that the grate can be cleaned during running hours. This means a great simplification.

A fundamental difference, however, between pressure and suction type does not exist, as the gasifying process is the same in both. For large units and wherever some of the gas is to be used for fuel purposes, the combined suction and pressure system is used to advantage, the producer proper being kept at negative and the other part of the apparatus

cent are used for heating the blast, 10 per cent are lost during charging, so that about 70,000 cubic feet are at our disposal. With 100-110 cubic feet of this gas 1 hp. is developed in a gas engine, which is one-seventh of gas required for getting the same result in the case of firing boilers.

The consideration of these facts has created a heavy demand for gas engines for the use in iron works. Koerting Bros., the leading German gas engine manufacturers, have sold over 150,000 hp. for this purpose. They are building their large engines 400 and above as two-cycle, as the four-cycle gets too bulky in these units.

Up to about 400 hp., however, the four-cycle engine is at present exclusively to be recommended. To give an approximate idea of the wide introduction of the four-cycle engines and producers, I want to mention that the above firm has in the last four years sold over 4,000 plants.

The following table will convey to the reader an idea of the

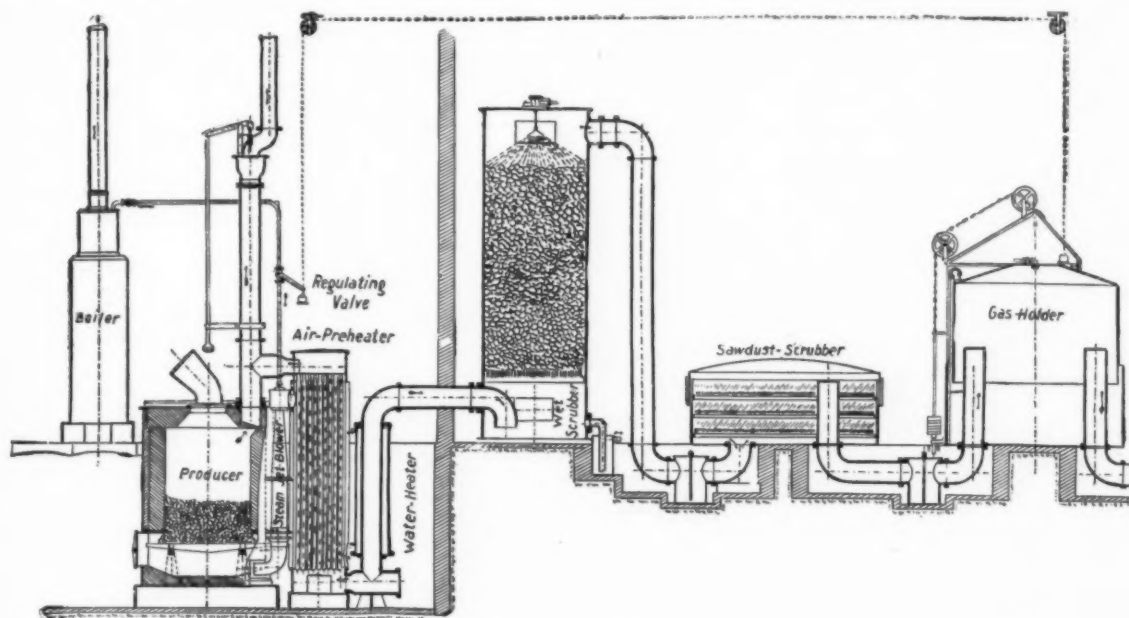


FIG. 1.—PRESSURE GAS PRODUCER.

at positive pressure, which is accomplished by inserting a fan behind the coke scrubber.

In the coke scrubber the gas is washed; ordinarily it is afterwards filtered in the so-called saw-dust purifier.

The size and construction of the purifying arrangement depends on the kind of fuel to be used; it has to be built in liberal dimensions, as otherwise considerable inconveniences and troubles are met with.

It is desirable to use in producers such fuels which, under ordinary conditions, yield a large amount of tar, such as bituminous coal, peat and lignite. The tar, besides being a loss as to its thermal value, is clogging up the pipes, and necessitates frequent cleaning.

A well constructed producer for such fuel has to gasify the tar, and utilize thereby the heating value of all its constituents.

For plants of large size, 2,000 hp. and above this is satisfactorily done in the Mond producer.

Of immense importance for the present gas engine industry is the utilization of gaseous by-products of certain industries, especially of coking plants and blast furnaces. While all of these gases were entirely put to waste up to a short time ago, they are now being more and more utilized in gas engines.

With every ton of iron about 157,000 to 158,000 cubic feet of blast furnace gas are generated. Of this about 40 per

saving in fuel in a suction gas-power plant as compared to steam. A 250-hp. plant will be considered with 3,000 working hours per year:

COMPARISON OF 250-HP. STEAM AND GAS POWER PLANT.

	Steam.	Gas.
Cost of complete plant, including foundations	\$13,000.00	\$16,250.00
Coal consumed per B. H. P.-hour, lbs.	3	1
Average cost of coal per ton.....	1.85	2.50

YEARLY EXPENSES.

Total cost of fuel including standby losses and loss for starting, 5 per cent for boiler, 10 per cent for producer	\$2,392.00	\$1,031.00
Attendance	1,500.00	1,050.00
Oil and cotton.....	250.00	120.00
12 per cent interest and depreciation..	1,560.00	1,950.00
Total yearly expense.....	\$5,702.00	\$4,151.00
Cost per hp.-hour.....	0.76	0.55

NOTE.—The building costs the same for steam and gas. Foundations for gas plant are 25 per cent cheaper than for

steam plant. Repairs on gas plant are only 50 per cent of the repairs on steam plant. As in most localities the difference between steam and producer coal is much less than shown in the table; the end result is generally more favorable for the gas plant.

These figures showing the superior economy of gas power will probably be criticised; one will find fault with the figures for the first cost, another with the figure for attendance, etc. This, however, is of no consequence, as sufficient figures are at hand showing actual results of German electric stations that are working with gas and stations using steam power. These figures, covering a great length of time, show clearly that 2-3

It is frequently mentioned that steam engines are able to carry a greater overload than gas engines, in which 10-15 per cent is a maximum. However, as the steam engine is built to be loaded to the best efficiency, an overload means an overstraining of the working parts, which is to be avoided.

Sufficient experience was gained in the last ten years showing the absolute reliability of the gas engine, and a very large number of German industrial and electrical power plants depend entirely on gas power.

A change is taking place gradually in prime movers. The gas engine will more and more replace the steam engine to the advantage of our industries. Everybody, however, who thinks of installing this new motive power ought to examine carefully what is offered to him, as the comprehension and understanding in this field is much more difficult than with steam engines.

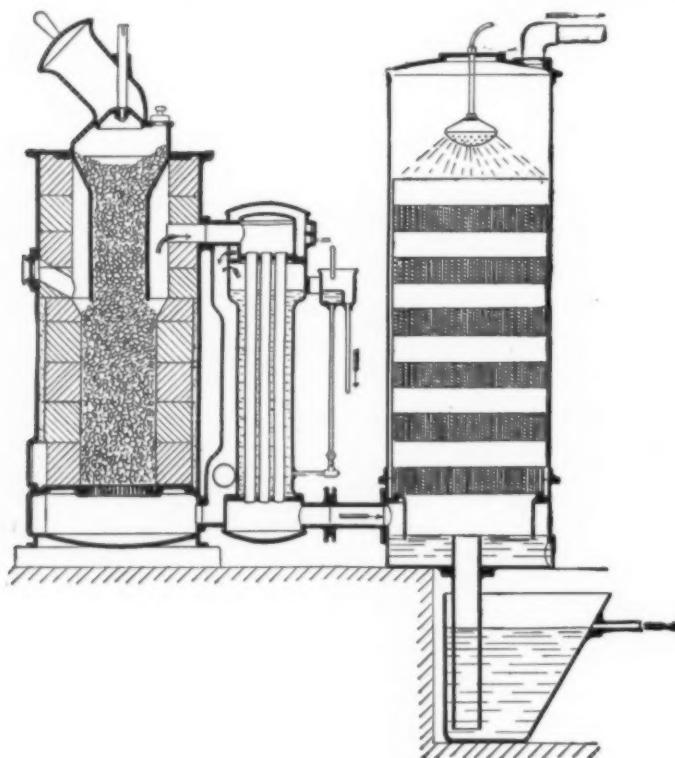


FIG. 2.—SUCTION GAS PRODUCER.

times as much total coal is used for steam power as compared to gas power.

An 80-hp. Koerting gas engine and producer, which is running at the electric central station in Lauterberg, Germany, has developed during the test run 1 hp.-hour with 0.77 pounds of coal. Such results naturally can be obtained only with the very best gas engines.

Another Koerting suction gas plant of 150 hp., which was started a short time ago at the electric central station in Doebelin, Saxony, showed the following results, using coal as fuel:

The generator, belt connected to engine, developed 98.27 kw. (guarantee 95 kw.). At an efficiency of 90 per cent of the generator and 5 per cent loss in the belt drive, this is equivalent to 154.2 hp. The coke consumption per B. H. P. hour was during the 10-hour test 1.085 pounds (guaranteed 1.1 pounds). The oil consumption was 1.86 gr. per B. H. P. hour.

The efficiency of the boiler is largely decreasing at low load and overload, while the economy of the producer remains constant within very wide limits.

Gas engines show the greatest economy at full load, while steam engines have it below this point. In both kinds of engines there is a point of highest efficiency. Up to and from this point the economy is decreasing.

Electro-Cyanide Process.

An interesting combination of a cyanide agitator, amalgamating tables and electrolytic precipitation in a single compact apparatus is found in the Garvin cyanide machine, built by the Garvin Cyanide Extraction Co., of Portland, Ore. The adjoining illustration shows the construction.

The method of agitation may first be described. A tank *A* with a conical bottom is supported in a wooden frame, and is filled with ore and solution, the depth of solution above the ore being at least 1 foot (indicated in the diagram by the distance between "solution line" and "pulp line"). *B* is the precipitating tank, which will be described later on. The solution is drawn from the precipitating tank *B*, and its flow is regulated by valve *K*, a pipe connection being provided with the bottom of the tank *P*. At the latter place a second valve *L* allows drawing off a quantity of the settled pulp discharge into connection *P*, where it mixes with the solution drawn from the precipitating box *B*, and flows to the pump (shown at the left hand). There it is pumped up to the shaking amalgamating table *C*, which will be dealt with below. From the amalgamating table *C* the pulp passes into the hopper *J*, which discharges it at a given point into the tank *A*, as clearly shown in the diagram. A

cone-shaped spreader *N* is placed in the bottom of tank, insuring a thorough circulation of the pulp and preventing it from funnelling or channelling.

It will be seen that the whole agitation is perfectly under the control of the operator by means of the two valves *K* and *L*. By opening the valves one can get as violent an agitation as may be desired. The amount of pulp that can be handled in the machine is large, the only limit being that the solution at the top of the tank must be less dense than what the pump will handle, so that it can be thickened to the consistency that will pump by opening the bottom valve.

The shaking amalgamating table *C* serves for amalgamating any coarse particles of gold that may be in the ore. The baffle boards *E* are arranged in this box so the discharge can be higher than the copper amalgamating plate, and the baffles will keep the pulp stirred up.

It remains to describe the precipitating box, which, in some respects, is the most interesting part of the apparatus. It is well known that electrolytic precipitation has been used successfully on a very large scale in South Africa, and in a few instances in this country and in Mexico. But the Garvin method of precipitation contains some peculiarities, mainly due to his using a mercury cathode and thus recovering the gold in form of amalgam. Of course, the mercury cathode is well

known to electrochemical engineers from the Castner-Kellner process of electrolysis of sodium chloride and from applications in the metallurgy of zinc, but it does not seem to have been employed before in the electrometallurgy of gold. At least, the mechanical arrangement of the mercury cathode in the Garvin apparatus is decidedly novel.

The solution is drawn or decanted from the top of tank *A* through outlet *O*, and passes then into the precipitating tank *B*. This is a box, rectangular in shape, with a circular bottom. Mounted in the bottom and the top of this box are two shafts with sprocket wheels on each end of shafts, and link chains or belts are fastened to them, and fastened to corresponding links of the chain are strips of copper, as shown by letter *G*. This is connected to negative pole of the dynamo, and is therefore called the cathode roller.

On each side of this roller is suspended a piece of sheet iron, which serve as anodes. In the bottom of this box is placed a quantity of mercury so that the lower part of the cathode roller *G* is immersed in it, and as the cathode is kept revolving it is continually being re-amalgamated. As the solution passes through this box the electric current precipitates the values from it, which are deposited in the cury forming the amalgam.

The solution as it passes through this box is, of course, muddy, as all of the light slimes will not have settled in the main tank *A*, but as the roller cathode is continually revolving and passing through the bath of mercury a coating of slimes does not form on the cathode and prevent the values from getting to the mercury as the same is precipitated from the solution. There is nothing new in the idea of precipitating values from solutions into mercury, but in a good many methods the amount of mercury necessary to obtain a sufficient cathode surface is prohibitive; but in this case it will be seen that a very large cathode surface is obtained with a small amount of mercury.

Heretofore there has also been a good deal of trouble in precipitating during the agitating process, for the reason that if the ore was heavy in sulphides the action of the electric current would decompose them and change the chemistry of the solution. While with this machine, as the pulp is discharged into the main tank *A* the ore will settle to the bottom of tank, and only the very lightest slimes will pass through the precipitating box; hence the electric current is not applied to the main body of ore.

If we finally look at the apparatus as a whole it will be seen that it combines the following functions after ore and solution have been placed in it: Decantation; electrolytic precipitation of the values from the solution; at the same time drawing the ore from the bottom of the tank and mixing it with the pre-

cipitated solution and pumping the mixture back to the top of tank; finally recovery of coarse gold particles by amalgamation; and so on.

Ferro-Alloys.

The interesting illustrated booklet on High-Grade Alloys published by Messrs. Geo. G. Blackwell, Sons & Co., Ltd., the old well-known ferro-alloy firm of Liverpool, has just appeared in its fourth edition. It contains much useful information. The following notes are abstracted from this booklet:

In the introduction it is pointed out that steel manufacture has now passed beyond the old "rule of thumb" methods of years ago, and has become a scientific process, a modern steel works being absolutely incomplete without its staff of trained chemists. For special work carbon steel does not answer requirements; and alloy steels have stepped into the gap. Armor plate, armor-piercing projectiles, guns, bullet-proof sheets, high-speed steel, motor car forgings and castings, etc., etc., are no longer made of carbon steel, but alloy steel. By alloying the rarer metals with steel, each metal having its own particular properties and effect, steel manufacturers have before them a field for making steel to answer practically any specification however severe.

The development of the electric furnace has enabled the manufacturer to place at the disposal of the steel men the metals and ferro-alloys practically unheard of a few years ago, and of a purity and excellence that would be impossible to surpass. (Concerning electric furnace methods of making ferro-alloy see, for instance, our Vol. II., p. 349, 395, 449.) Messrs. Geo. G. Blackwell, Sons & Co. state that they control the largest and most modern electric furnace works in the world, having a maximum of 42,000 hp., and that they own and operate their own ore mines.

In connection with the use of ferro-alloy the thermal treatment of steels is, of course, of the greatest possible importance, but this will not be referred to in the following notes, which are restricted to a summary of the applications of the various ferro-alloys:

Ferro-Chrome.—It is used extensively for armor plates, armor-piercing projectiles, wire, bullet-proof steel, tool steel, high-speed steel, high-grade castings, stamper shoes and dies, safe steel, tyres and axles, springs, razor and cutlery steel, and for many other purposes. As an instance of what may be accomplished with chrome-steel it is mentioned that it is possible to make armor-piercing chrome-steel projectiles of

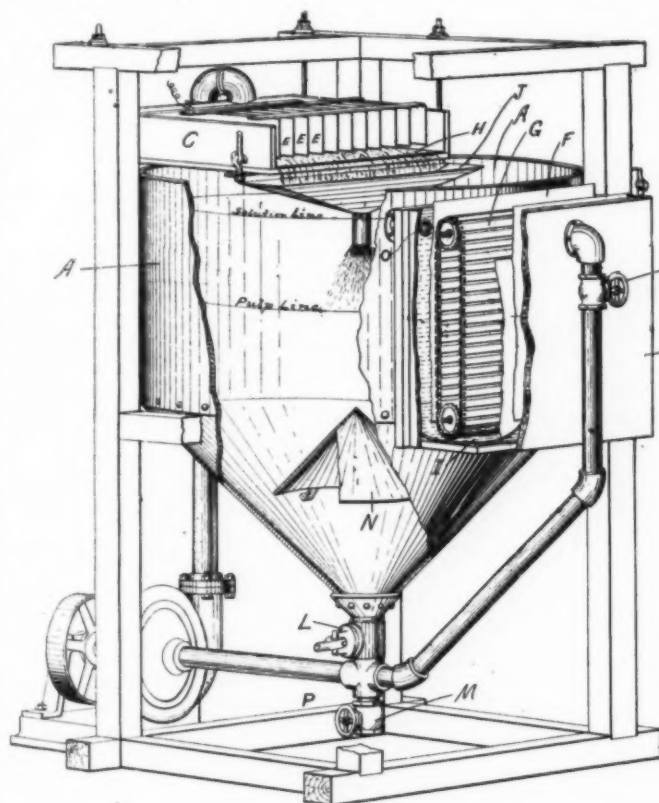


FIG. 3.—CYANIDE MACHINE.

6-inch calibre, able to penetrate compound armor plates 10½ inches in thickness, thereby remaining practically unaltered in form, while projectiles 13.5 inches in diameter, fired from the 63-ton B. L. gun, were able to penetrate over 3 feet of steel or wrought iron. T. E. Vickers has formerly pointed out the difficulty of getting ferro-chrome containing a small amount of carbon. But this difficulty has been overcome in recent years. (Mainly a result of electric furnace processes, by which it is possible first to reduce the amount of carbon in the ferro-alloy and second to make a high-percentage alloy; the higher the percentage the less, of course, the impurities introduced into the steel with the alloy.)

According to L. Guillet the chrome-steels may be divided into three classes:

(1) Steels containing from 0.0 to 7.0 per cent Cr, are similar to ordinary carbon steels, except that the breaking strain rises with the percentage of Cr.

(2) Steels containing 7 to 22 per cent Cr, that the breaking strain and elastic limits are very high, and the elongation and contraction low.

(3) Steels containing over 22 per cent Cr, that the breaking strain is medium, the elastic limit relatively low, the elongation and contraction relatively high.

The shock tests made from Frémont's method, and the hardness test (Brinell) confirm the division into three classes. The 7 per cent and under samples, being hard, and resisting impact; those with 7 to 22 per cent Cr, yielding medium results in both cases, and those containing more than 22 per cent Cr, being highly brittle. The high percentage of Cr samples, notwithstanding their brittleness, give high elongation and contraction results.

Concerning the magnetic properties it may be mentioned that the coercive force is great, especially when the material is hard. In this state Hopkinson considers that it should make good permanent magnets—a fact confirmed by Bottomley's tests.

Ferro-chromium can now be made, containing some 60 to 68 per cent of chromium and small amounts of carbon. The following is an analysis given by Geo. G. Blackwell's Sons & Co. for their most refined ferro-chrome: 63.586 Cr, 35.576 Fe, 0.65 C, 0.14 Si, 0.028 S, 0.1 P. They furnish ferro-chrome in five quantities: A ordinary quality, about 9 per cent C; B quality, 6 to 8 per cent maximum C; C quality, 4 to 6 per cent maximum C; D quality ("No. 2 refined"), 1 to 2 per cent maximum C; E quality ("No. 1 refined"), ½ to 1 per cent maximum C.

Chrome-Nickel-Iron Alloy.—The analysis of a sample is 52 Cr, 18 Ni, 28.96 Fe, 0.50 C, 0.50 Si, 0.03 S, 0.01 P. This alloy is used for special work, chrome-nickel steel being principally used for armor plates.

Ferro-Tungsten.—Tungsten largely increases the strength of steel. The hardness of tungsten steel is not impaired by heat, and as a consequence may be driven much faster than carbon steel when used as machine cutting tools.

A very distinctive characteristic of tungsten steel is its ability to retain magnetism.

Tungsten is more generally used for manufacture of self-hardening and high-speed steel for tools.

The question of the percentage of carbon is undoubtedly of great importance, and whereas it was customary in the old self-hardening steels to have high-carbon contents, it has now been found that for the best high-speed steels a low percentage of carbon undoubtedly gives the best results. To get uniformity of results it is necessary that the content of carbon in the ferro-tungsten should be exactly known. Geo. G. Blackwell, Sons & Co. supply ferro-tungsten in three qualities; the figures in parenthesis giving the analyses of three samples: No. 3 (65.7 W, 31.00 Fe, 2.92 C), No. 2 refined (75.25 W, 22.997 Fe, 1.62 C), No. 1 refined (85.79 W, 13.50 Fe, 0.60 C, W and Fe together 99.29 per cent).

Tungsten-Nickel Alloy.—Two grades, one about 75 per cent W, 25 per cent Ni, the other 50 W and 50 Ni (½ to 1 C and 0.25 to 0.50 Si) are used in works in Continental Europe in the construction of gun-carriage parts.

Ferro-Molybdenum.—With respect to forgings, molybdenum increases the elongation and elastic limit of steel very considerably, and is stated to be much more valuable than nickel in this respect. It has been found that by the addition of 0.25 per cent of molybdenum the elongation has been increased from 4 per cent up to even 45 per cent. It will be seen, then, that for all classes of forgings—particularly large crank and propeller shafts, etc.—this metal is of the greatest value. For large guns, rifle barrels, etc., where great strength and resistance to the erosion from the use of nitrate powders is required, molybdenum steel is invariable. There is also a future for molybdenum steels for shells. An exceedingly hard and tough armor-piercing shell can be made from this alloy. "Molybdenum-chromium shells are certain to displace chromium-nickel shells."

For wire-drawing the large increase in elongation at a comparatively small cost is very important. "Very high tensile tests can be obtained."

For plates for high-pressure boilers a steel containing 0.25 per cent molybdenum with chromium "is certain to give splendid results," especially for boilers for torpedo boats, where the maximum strength and elastic limit is required. Lighter plates could be used combined with greater strength.

Molybdenum steel is specially adapted for motor-car forgings and castings. It is also claimed that molybdenum steel is more suitable than tungsten for permanent magnets.

Finally with respect to the important subject of high-speed tool-steels it is stated that molybdenum, suitably alloyed, produces high-speed steels infinitely superior to the best tungsten-chromium steels. In support of this statement a paragraph is reproduced from Mr. J. M. Gledhill's valuable paper on "High-Speed Steel," read before the Iron and Steel Institute meeting in New York in 1904, and also the remarks made by Prof. J. W. Richards in discussing this paper. Mr. Gledhill says: "The influence of this element (molybdenum) at the present time is under investigation, and our experiments with it so far produced excellent results. It is found that where a large percentage of tungsten is necessary to make a good rapid steel, a considerably less percentage of molybdenum will suffice. A peculiarity of these molybdenum steels is that in order to obtain the greatest efficiency they do not require such a high temperature in hardening as do the tungsten steels, and if the temperature is increased above 1,000° C. the tools are inferior and the life shortened."

Prof. J. W. Richards said: "The mention of the use of molybdenum brings to my mind the difference between the practice in Europe and America. On looking over that very fine work on steel, recently written by Harbord, the word, molybdenum, is not to be found in the book, and the statement just made by Dr. Matthews that several hundred tons of molybdenum have been used in America would tend to show the difference in the practice in the two countries. Mr. Pye-Smith says that high-speed tool steel is very hard and brittle, and in Mr. Gledhill's paper the influence of the carbon in increasing brittleness is emphasized, it being pointed out that from 0.4 to 0.9 per cent is the most advantageous quantity of carbon to be used if brittleness is to be avoided. The particular advantage of using molybdenum is that it gives all the desirable qualities of high-speed steel with carbon kept below 1 per cent. So that the desirable qualities are obtained by the use of molybdenum and quite low in carbon, thus avoiding the hardness and brittleness caused by the higher carbon used in high-speed steels having no molybdenum—the ordinary high-speed tungsten steels."

Geo. G. Blackwell, Sons & Co. supply ferro-molybdenum in three grades, the analyses of three samples being added:

	Mo	Fe	C	Si	S	P
Ordinary 80 to 85% grade	85.80	10.963	3.070	0.110	0.050	0.007
Refined 80 to 85% grade	85.200	14.047	0.450	0.252	0.031	0.020
Refined 50% grade..	50.311	48.920	0.350	0.300	0.030	0.020

Molybdenum-Nickel.—Nickel, alloyed with molybdenum, renders the alloy very readily fusible, and permits of the manufacture of perfectly homogeneous steel. A small addition of a 75 per cent Mo, 25 per cent Ni alloy to high-percentage nickel-steel boiler tubes has a remarkable effect. This alloy is extensively used in Continental Europe for this purpose. Small additions of molybdenum are recommended to all high-percentage nickel steels.

Ferro-Vanadium.—The following analysis of a sample of ferro-vanadium is given: 50.50 V, 45.151 Fe, 4.07 C, 0.09 Si, 0.08 Mn, 0.07 Cu, 0.019 S, 0.020 P.

Ferro-Titanium.—Titanium introduced into steel increases the ductility, even in steels high in carbon. This increase is very much marked, even when only a small quantity of titanium is added.

It is suggested also that titanium acts in a similar manner to manganese, removing oxygen from steel in the Bessemer, open-hearth and crucible processes; and, as titanium also combines with nitrogen, it will probably be found to be a very useful deoxidizer.

A great deal has been written about the use of titanium in iron foundry practice. It is claimed that titanium gives a greater density to the iron, and increases the transverse strength considerably, and also gives a harder chill.

The following analysis of a ferro-titanium sample of Geo. G. Blackwell, Sons & Co. is given: 53.00 Ti, 41.87 Fe, 3.28 C, 0.30 Al, 0.29 Mg, 1.21 Si, 0.03 S, 0.02 P. (Concerning ferro-titanium and ferro-vanadium, see also the articles by Rossi in our Vol. I., p. 523, and Hans Goldschmidt in our Vol. III., pp. 168 and 226.)

Ferro-Nickel.—This is supplied in grades of 25, 35, 50, 75 and 85 per cent. Outside the nickel and iron, the impurities are 0.50 to 1.00 per cent C, 0.20 to 0.30 Si, 0.01 to 0.02 S, 0.02 to 0.03 P. The alloy is "in such a form that even very small percentages of nickel can be readily introduced into the steel or iron, the nickel becoming thoroughly mixed through the mass, the ingots being perfectly homogeneous." The alloy is malleable and homogeneous, and can be rolled, drawn or worked readily.

This alloy is also largely used in brass and bronze, to add nickel and iron to increase tensile strength, etc.

Ferro-Silicon.—Silicon pig-iron has been used for many years in steel practice and in the iron foundry. These irons contain from 9 to 20 per cent Si. They are now being replaced by electric-furnace ferro-silicon. Their advantages were pointed out in our Vol. II., p. 122, together with applications.

Geo. G. Blackwell, Sons & Co. give the following analysis of samples of their four commercial grades:

	25 to 35%	50%	75%	95%
Si	32.70	48.70	75.80	94.80
Fe	65.50	50.84	23.97	4.99
Al	0.13	0.17	0.08	0.10
Mn	0.31	0.13	0.11	0.08
S	0.04	0.03	0.02	0.02
P	0.05	0.04	0.02	0.01
C	0.27	0.09	0.00	0.00

Ferro-Manganese.—Manganese has occupied a very prominent position in metallurgy for many years past, and its value is largely due to its great affinity for oxygen. Mr. Hadfield is responsible for the discovery of the remarkable steel known as "Hadfield's Manganese Steel"—steel containing from 7 per cent to 20 per cent of manganese, combining great strength with toughness and hardness. Carbon steels are hardened by heating and quenching water; but these manganese steels are

somewhat softened and decidedly toughened by heating and rapidly cooling in water. These steels are largely used for special castings, such as crusher jaws, mining and milling machinery, tramway points and crossings, etc.

The use of manganese in foundry practice is a subject which is full of interest. Small quantities of ferro-manganese are used for softening, strengthening and purifying hard or chilling irons. The car-wheel makers find manganese specially beneficial, and find it most convenient to use the ferro-manganese in a powdered state. Its action, when added in this condition in the ladle, is very powerful. It permits of the remelting of a large proportion of scrap car-wheels and poor grades of pig. About 1 pound of powdered ferro-manganese to 300 pounds of metal is used, and should be thrown into the bottom of the ladle, and the molten iron immediately tapped on to it. In making chilled castings, the use of powdered ferro-manganese permits of the depth of chill being regulated. To increase the chill add slightly less ferro-manganese; to reduce the chill add slightly more.

Generally speaking, the use of ferro-manganese in a foundry acts:

As a deoxidizer, reducing the chance of blow-holes.

Assists in eliminating sulphur.

Regulates the depth of chill in chilled castings.

In small proportions softens hard or chilling irons.

In larger proportions (about 1 per cent) strengthens soft irons.

Generally improves and toughens all irons.

(An excellent article on the uses of manganese, by Dr. Hans Goldschmidt, was published in our Vol. II., p. 146. This article also contains interesting notes on the uses of chromium and on some special alloys.)

Manganese-Silicon Alloys.—Large quantities of silico-spiegel, or alloys of manganese and silicon, are being used by steel manufacturers for deoxidizing, and for certain classes of work—particularly steel foundry practice—manganese alloyed with silicon gives better results than manganese alone. Up to a short time ago the only silico-spiegels available were those made in the blast furnace, containing about 10 per cent silicon and 18 to 20 per cent manganese. The developments of the electric furnace, however, have resulted in the production of very high percentage silico-spiegels, which are much purer than those made in the blast furnace.

The same conditions apply to the use of these high percentage silico-spiegels as to the use of the high percentage ferro-silicons, and it is expected that these electric silico-spiegels will in time displace the lower grades made in the blast furnace.

These manganese-silicon alloys are supplied by Geo. G. Blackwell, Sons & Co. in the following five grades: 75 per cent Mn and 25 Si, 70 to 75 Mn and 25 to 20 Si, 25 Si and 55 Mn, 20 to 22 Si and 50 to 52 Mn, 20 to 22 Si and 36 to 40 Mn.

Ferro-Phosphorus.—Some two or three years ago, Messrs. Geo. G. Blackwell, Sons & Co. were asked by some large steel manufacturers in the United States whether they could produce a quantity of ferro-phosphorus, to contain as high a percentage of phosphorus as possible. After considerable experiments they succeeded in producing this alloy, and have since delivered several thousands of tons to the steel works in America and elsewhere.

This ferro-phosphorus is useful in the basic steel process for enriching the slag. It has been found that in steel for sheet purposes, particularly tin plates, steel with phosphorus rolls with a better finish.

"It seems strange that phosphorus should actually be used in steel manufacture, whereas it was always previously considered a most objectionable element; but it is a fact that the presence of phosphorus in many steels is actually desirable, and it is only lately that these properties are becoming recognized."

It has been noted that some rails high in phosphorus have been remarkable for their long life. It has also been found

that under certain conditions carbon and phosphorus may replace each other, and that by lowering the carbon and raising the phosphorus the steel rolls with a better finish, and that the finished product from the rolls has a desirable surface (or skin) which is not found in lower-phosphorus or higher-carbon steel.

Geo. G. Blackwell, Sons & Co. have produced ferro-phosphorus in two grades: 16 to 20 per cent phosphorus and 20 to 25 per cent, of which the following analyses are given:

	P	Fe	Si	C	S	Mn
No. 1.....	24.00	73.30	2.47	0.03	0.08	0.10
No. 2.....	17.5	76.20	0.42	0.27	...	5.75

Besides notes on ferro-alloys, the booklet of Blackwell, Sons & Co. contains some information on the use of copper-silicon and manganese-copper, and on the employment of fluorspar in open-hearth steel works.

Notes.

Vanadium.—We have received from the Vanadium Alloys Co. samples of the vanadate of iron made by this company in their Colorado plant, which was described in our May issue, page 195.

General Chemistry.—Prof. W. Ostwald's six lectures, held at Columbia University in the beginning of this year, on the historical development of general chemistry, are now being printed in full in the *School of Mines Quarterly*. The January issue contains the first two lectures, the first dealing with elements and compounds, the second with combining weights and atoms.

Kryptol.—The Kryptol Stock Co. has sold out its whole business to the Machine Co. of the North German-Lloyd, in Bremen.

Chemical Control of Cane Sugar Factories.—W. D. Horne gives in the January issue of the *School of Mines Quarterly* notes on a uniform method of chemical control of cane sugar factories working under diverse conditions. These notes refer to standardizing apparatus, measurements, sampling and analyses.

Regeneration of Air.—In *Glueckauf* of May 12, M. Bamberger and F. Boeck discuss the chemistry of the use of potassium-sodium peroxide for regenerating air in closed spaces, and especially for use in mines. The article is mainly of a polemical nature replying to a recent article of Michaelis. The subject is of interest with respect to the use of "oxone"; i. e., fused sodium peroxide, for the same purpose, as manufactured by the Roessler & Hasslacher Chemical Co., of New York. Some interesting notes on the use of oxone for this purpose were given in a lecture of Mr. FitzGerald, on page 166 of our May issue, while a more detailed account of extended experiments in this line, made by Messrs. Brindley and von Foregger, is given in their American Electrochemical Society paper published elsewhere in this issue.

Electric Testing Laboratories.—The purpose and equipment of the Electric Testing Laboratories of New York City—well known to members of the American Electrochemical Society from the most enjoyable meeting held there last year by the New York Section—was the subject of an interesting paper presented last November by Dr. Clayton H. Sharp before the American Institute of Electrical Engineers. This paper has recently been issued in form of a neat pamphlet, with numerous illustrations. In this connection it is interesting to note that Mr. N. D. Macdonald, of the Electrical Testing Laboratories, is dividing his time this month between the Locke Insulator Works, Victor, N. Y., and the Thomas Insulator Works, Lisbon, Ohio, inspecting and testing high-tension insulators for several transmission plants in the West.

Ithaca Meeting of the American Association for Advancement of Science and of the American Chemical Society.—The meeting will be held from June 29 to July 3. Some sections intend to make this essentially a field meeting, and the local committee has arranged excursions accordingly. For the American Chemical Society visits to various points of interest in the buildings and upon the grounds of Cornell University, in charge of several committees, have been arranged for the afternoon of Thursday, June 28. On Friday, June 29, the members of the Chemical Society will take a boat ride on Cayuga Lake, with dinner at Sheldrake. This excursion will take place after the dedication of the new Physical Laboratory (Rockefeller Hall).

American Foundrymen's Association.—The American Foundrymen's Association and the Associated Foundry Foremen will meet for their annual convention in Cleveland on June 4 to 7. A large attendance is expected. An excellent programme has been prepared; among the papers to be presented are the following: A. E. Outerbridge, Jr., on the beneficial effects of adding high-grade ferro-silicon to cast-iron; F. L. Antisell, on electricity in the foundry; W. M. Carr, on developments in the thermit process in foundry practice; Dr. R. Moldenke (the distinguished Secretary of the Association), on foundry tests of coke made by the United States fuel testing plant; C. Vickers, on alloys; R. H. West, on air-furnace construction and operation; C. H. Benjamin, on tests of cast iron. The entertainment programme includes a theater party on June 5, and automobile ride for the ladies on the next afternoon, while the gentlemen visit at the same time some factories in Cleveland; a visit to one of Cleveland's pleasure resorts the same evening; a steamboat ride to Lorain, with a visit to the ore docks, blast furnaces and foundry on June 7, and a smoker on the evening of June 7.

Chemical Engineering.—A recent issue of *The Technical World Magazine* contains a suggestive interview with Mr. Edward Gudeman, the well-known consulting chemical engineer of Chicago, on the ever-widening opportunities in the comparatively new field of chemical engineering. "The chemist can give the promoter the formula for bringing about the chemical action he needs in order to produce his article. The engineer can give him the plans required for the machinery. The engineer cannot tell what formula is needed. The chemist with chemical knowledge not only knows how to deal with the elements necessary, but he also knows how to design the machinery needed to utilize the elements and direct the forces. It might be said, and is said, that the chemist can be secured to do his part in solving the joint problem, and that the engineer can be found to do his. This is true; but we assert that the most satisfactory work will be produced by the man who can take the problem in its entirety and handle all of it." Specific examples are given from railway practice, the iron and steel industry, etc. Mr. Gudeman urges that a thorough knowledge of chemistry should be a part of the average engineer's training. He finds that one reason for Germany's supremacy in some commercial and manufacturing lines is the willingness and readiness of its manufacturers to utilize chemical discoveries.

Utilization of Blast Furnace Gases.—Many of the steel mills, iron works and other furnace plants are making great progress in the utilization of blast furnace gas. This development (which we have carefully covered in our columns) has chiefly become possible because within the last few years the gas engine business has made enormous strides. A gas engine unit of 100 hp. was, about five years ago, a curiosity, while to-day such engines are manufactured with a capacity that runs as high as 5,000 hp. Gas engines have found a great field of utility in mills, mines and factories where their introduction offers many points of advantage. It saves much space, because boiler room is eliminated. Its operation is more uniform and less costly than the steam engine. The manufacture of pro-

ducer gas, which has also reached a state of high development recently, is another feature which makes the use of the gas engine desirable. In the mills, however, the blast furnace gas, which would otherwise not be fully utilized, is now used for the operation of gas engines, which furnish power in various forms throughout the mills. The Lackawanna Steel Co. was the enterprising pioneer in this field. More recently the United States Steel Corporation began the operation of gas engines with producer gas, and that company has a number in use. In the rail mill at Braddock, Pa., gas engines run several immense electric generators, which furnish power to the rolling mills and other machinery, and these gas engines are operated by blast furnace gas. In addition, the American Steel & Wire Co., which is an underlying company of the United States Steel Corporation, is now equipping the plant at Worcester, Mass., with an 800-hp. gas engine to operate the mill machinery. All of these gas engines are manufactured by the Westinghouse Machine Co., of East Pittsburg, Pa., which firm makes a specialty of their production, and produces gas engines as large as 5,000 hp.

Gas Power.—The important place which the large gas engine has won for itself in America is plainly evidenced in the attitude of the foremost engine builders in the country toward it. The Allis-Chalmers Co., of Milwaukee, has undertaken the production of large gas engine units as well, and has developed within the past year a distinctive Allis-Chalmers type of gas engine. The latest evidence of the growing favor toward large gas engines is the recent purchase by the Carnegie Steel Co., for its Homestead Mills, of four gas-driven blowing-engine units, each consisting of a horizontal twin tandem, double-acting Allis-Chalmers gas engine of 3,000 hp., having two direct blowing tubs with a capacity to deliver 30,000 cubic feet of free air per minute against a pressure of 18 pounds per square inch. These blowing tubs, which are so designed and proportioned that they can be operated at any pressure up to 30 pounds, are of the slick type, covered by patents owned by the Allis-Chalmers Co. The Carnegie Co., in addition to the four units above described, has ordered an electrical generating unit for installation in the same mills, consisting of a horizontal twin tandem Allis-Chalmers gas engine, direct connected to a 2,000-kw, 25-cycle, three-phase generator, wound for 6,600 volts. The engine ends of these five units are to be exact duplicates with the exception of the fly-wheels, which, in the case of the blowing engines, where the demands for close regulation are not so severe, will be somewhat lighter. The generator for this unit will be built after the well-known designs of Allis-Chalmers revolving field machines, at the company's electrical works, Cincinnati, Ohio. This order followed shortly that of the Illinois Steel Co., of Chicago, calling for two 2,000-kw. Allis-Chalmers gas engine generating units of similar design.

Niagara Bill.—While we are going to press it is reported from Washington that, without debate or division, the House of Representatives passed the Burton bill for the preservation of the scenic beauty of Niagara Falls, as reported from the committee on rivers and harbors. The measure provides that the Secretary of War shall be authorized to grant permits for the diversion of water in the United States from the Niagara River to companies, individuals and corporations which are now actually producing power from the river; also for the transmission of power from Canada to companies legally authorized therefor, but only to the amount now actually in use. The Secretary of War, however, may grant revocable permits from time to time for the diversion of additional water to such amount as, in connection with the amount diverted from the Canadian side, shall not injure or interfere with the navigability of the river and its integrity and proper volumes as a boundary or the scenic grandeur of the falls. The amount of power which the bill permits to be transmitted to the United States from Canada is fixed at 160,000 hp., pro-

vided that the Secretary of War may issue revocable permits for the transmission of additional electrical power so generated in Canada, but in no event shall the total amount together with what may be generated and used in Canada exceed 350,000 hp. This amount is fixed as a limitation, and it is not to be construed as directing the Secretary of War to issue permits to this extent. Violation of the law is declared to be a misdemeanor, and the penalty \$500 to \$2,500 fine, or imprisonment, in case of a natural person, not exceeding one year, or both in the discretion of the court. The act is to remain in effect for three years, and the President is requested to open negotiations with Great Britain for the purpose of effectually providing by treaty for regulation and control of the waters so as to preserve the scenic beauty of the falls and the rapids to the river. The bill will now go to the Senate.

Personal.

Mr. HERBERT HAAS, consulting metallurgical engineer, with offices formerly at 604 Montgomery Street, San Francisco, informs us that since his office became an entire loss in the disastrous conflagration which befell San Francisco, he has now temporary offices with the Union Iron Works Co., at Patrero, San Francisco.

Dr. OSKAR NAGEL, who is well-known to our readers by his excellent and authoritative articles on gas power, is now connected with the De La Vergne Machine Co. as special engineer of their rapidly extending gas power department. This company builds the celebrated Koerting gas engine.

Prof. WILHELM OSTWALD has resigned the professorship of chemistry at the University of Leipzig. According to a rather mysterious cablegram, published in daily newspapers, this step is "a result of his displeasure at the lack of support accorded his chemical researches." Dr. Ostwald will establish a private laboratory. Prof. Ostwald was the first German professor selected to come to this country under the arrangement for the mutual exchange of professors between American and German universities. He delivered, last winter, a series of lectures at Harvard and later a shorter series at Columbia. The very enjoyable reception tendered to him by the New York Section of the American Electrochemical Society just before his departure for Europe is certainly still fresh in the memory of many of our readers.

Mr. EDGAR A. ASHCROFT sailed for Norway on May 23 on the steamship "Helig Olaf." He was accompanied by Mr. I. J. Moltkehanen, who will assist him in starting the Norwegian plant for the electrolytic production of metallic sodium by the process described by Mr. Ashcroft in his *Electrochemical Society* paper published elsewhere in this issue. Mr. Ashcroft intends to come again to this country in autumn, and will attend the meeting of the Electrochemical Society in New York in October.

Dr. HENRY NOEL POTTER, special engineer of Mr. George Westinghouse, sailed for Europe on May 30 on the "New Amsterdam." Dr. Potter expects to return in the beginning of August.

Dr. PAUL HEROULT sailed with his family for France on May 31 on the steamer "La Provence." He will return to this country in about two months, since the developments of his electric furnace process in the iron and steel industries are rapidly making progress. His representatives in this field are Mr. R. H. Wolff for the United States, and Mr. R. Turnbull for Canada. Mr. Wolff has been for many years a maker of high-grade steels and wires in this country, and was during the last five years the foreign representative of the Crucible Steel Co. of America. Mr. Turnbull is intimately acquainted with the Héroult process, having been connected as a special

engineer with Dr. Héroult abroad as well as at the recent successful experiments at Sault Ste. Marie (see our April issue, p. 124).

AT THE CELEBRATION of the seventy-fifth anniversary of the Royal Prussian Institute of Technology, of Hanover, Germany, the honorary degree of Doctor of Engineering was conferred on Mr. ERNST KOERTING, the noted European engineer, and of the well-known firm of Gebr. Koerting, A. G. Koertingsdorf, Hanover, for his scientific researches and discoveries in gas engines and other important branches of engineering. Dr. Koerting lives in Pegli, Italy. He is interested in a number of large enterprises in this country, among them the De La Vergne Machine Co., of New York, as well as the Schutte-Koerting Co., of Philadelphia, and is at present sojourning in this country.

Mr. F. W. HASKELL, the well-known president of the Carborundum Co., of Niagara Falls, has contributed an interesting and sarcastic article on "Hysterical Insurance Reform" to the May issue of *Moody's Magazine*. It will be remembered that Mr. Haskell was a member of the Frick committee investigating the Equitable Life.

Digest of U. S. Patents.

Compiled by Byrnes & Townsend, Patent Lawyers, National Union Building, Washington, D. C.

DISCHARGES THROUGH GASES. OZONE.

(Continued from page 204.)

No. 427,744, May 13, 1890, T. F. Colin, Pittsburg, Pa.

Produces chlorine derivatives of methane by burning a mixture of chlorine and natural gas in suitable proportions. To produce chlormethane, burns a mixture of equal volumes of chlorine and marsh gas, passes the products through washing-jars or coke towers, wherein the hydrogen chloride is absorbed, thence through a water-cooled condenser, wherein higher methyl chlorides are liquefied, and finally passes the residual chlormethane through an alkaline solution, to remove traces of hydrogen chloride, through sulfuric acid to dry, and compresses at from 3 to 5 atmospheres in iron cylinders. For dichlormethane, burns a mixture of chlorine 2 volumes and marsh gas 1. Chloroform is produced from a mixture of chlorine 3 parts and marsh gas 1, passed through an externally-heated combustion chamber, through which a high-tension electric discharge is passed to induce and maintain combustion. The product, after the hydrogen chloride is washed out, is condensed and rectified by distillation, the fraction coming over between 61° and 62° C. only being collected.

No. 430,387, June 17, 1890, J. C. Kennedy, Detroit, Mich.

Places disc electrodes with opposed points on the ends of the conductors of a Holtz static generator. One conductor is hollow, and the ozone is withdrawn through it by a suction pump, and delivered, under compression, to a reservoir.

No. 468,326, Feb. 9, 1892, Francois Broyer and Paul Petit, Tournus, France.

Ages alcoholic liquors by ozone. The ozonizer consists of a glass tube surrounding and inclosed, respectively, by the electrodes, two aluminium spirals. The whole is inclosed in a tubular glass air conduit. Oxygen from a holder is dried by calcium chloride, passed through three ozonizers in series, and thence in series through three wooden tanks containing the liquor. Each tank receives the ozone through a glass tube, so arranged that the escaping ozone produces a gyratory motion of the liquor. The spent gas may be directly returned to the oxygen holder, or redrawn, reozonized and passed through other tanks before return.

No. 470,425, March 8, 1892, Frederick M. Grumbacher, New York, N. Y.

Ozonizes air for use in theaters. Forces the air through

a chamber containing drying material, thence through a number of Siemens ozone tubes, and finally through an essential or volatile oil held in the bend of a U-tube. The pungent odor of the ozone is thereby removed without impairing its action.

No. 481,676, Aug. 30, 1892, C. C. Sharp, Chicago, Ill.

Ozonizer consists of an oval glass bulb, having a flaring mouth at one end. The bulb is partly lined with a ring of metal, serrated at its edge and constituting one electrode. Within the bulb and spaced away from its metal lining is a hemispherical metal cup, marginally serrated and having inwardly-projecting points. A patient to be treated is seated on an insulated stool, having a metal platform connected to a Wimshurst static generator, and inhales the ozone, the terminals of the ozonizer being connected to the same generator.

No. 483,745, Oct. 4, 1892, James W. Moliere, San Francisco, Cal.

Utilizes a Toepler-Holtz static generator for therapeutic purposes, by providing its glass case with flexible ozone inhalation tubes. A wire connected to one terminal of the machine leads through one tube and into its glass mouthpiece, to convey the electric discharge to the patient, seated on an insulated chair.

No. 487,390, Dec. 6, 1892, Oscar Frolich, Berlin, Germany.

Locates both electrodes on one side of the dielectric layer, a third insulated conducting body being placed near the opposite side. In one form the dielectric is a flat plate, having on one side spaced rectangular electrode coatings separated by a straight insulating rib. A metal plate is placed on the opposite side of the dielectric, being spaced therefrom to provide a passage through which the air to be ozonized is passed. Illustrates three modifications. In one the electrodes are ring-coatings on the outside of a dielectric tube and separated by an annular rib, a tubular metal body being arranged within and spaced away from the dielectric tube. Another form is similar, but the electrodes are arranged longitudinally outside the dielectric tube and separated by longitudinal ribs. In the last modification two separate electrodes, each consisting of a short dielectric tube with metal coating, the two supported at their ends in ebonite rings, surround but are spaced away from a tubular chamber coated with tin, through which water is passed for cooling. The dielectric material may be porcelain, earthenware, gelatine, enamel, wood, paper with insulation, papiermache, celluloid, guttapercha, caoutchouc or ebonite, and may be protected by a mixture of paraffin and wax.

No. 494,199, March 28, 1895, Thurston G. Hall, Chicago, Ill.

A heated fire-brick chamber contains a loose pile of thermo-electric cells, each comprising two concentric porous sand crucibles. Between the inner and outer crucibles is a mass of iron or carbon, and within the inner crucible a conductor of opposite polarity, such as copper or zinc. The metallic electrodes in the several cells are connected by wires, and the whole constitutes a battery, the current of which may be externally utilized. Gases, such as air or steam, are said to be subjected to an electrochemical or catalytic action by passing them through the heated chamber containing the battery.

No. 494,200, March 28, 1893, T. G. Hall, Chicago, Ill.

Utilizes the thermo-electric battery of the preceding patent for the production of illuminating gas, by passing a mixture of steam and products of combustion through the fire-brick battery chamber. The elements of the gaseous mixture thereby "separate or become separated into a nascent condition, and will then immediately recombine into a permanent inflammable compound gas."

No. 499,572, June 13, 1893, Marie P. Oudin, Paris, France.

Into one end of a flattened glass tube is sealed a binding post, in contact with hydrogen or partially-exhausted air therein, constituting one electrode. At the sides of the tube are metallic plate electrodes. Air rises between the plates and tube and the ozonized product escapes at the top through an inhaling tube.

8.